MICHIGAN DEPARTMENT OF TRANSPORTATION

MDOT

State Long-Range Transportation Plan 2005-2030

Economic Impact Analysis of the Michigan Transportation Investment Packages

Prepared for
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MI Transportation
MICHIGAN LONG RANGE TRANSPORTATION PLAN

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Executive Summary

MI Transportation Plan has set forth a vision for the future development of Michigan's transportation system and has identified alternative investment packages that will be necessary to move toward that vision. The primary focus of this report is to evaluate the economic impacts and implications arising from the transportation investment packages.

To accommodate future economic growth and to meet increasing demand on Michigan's transportation system, the Michigan Department of Transportation (MDOT) proposes several investment packages for improving and maintaining the transportation system assets which it owns, operates or funds. These investment packages include a base package for "Business as Usual," three alternative packages, and an "Investing to Achieve the Vision" package. The three alternative packages are designated as "Change the Mix," "Move Ahead" and "Flexible New Revenue" and represent different investment options to cope with the future demands on the transportation system. The intent of the investment packages is to improve and provide a better-maintained transportation system for Michigan residents and businesses, and offer multi-modal connectivity between different transportation modes and programs.

In order to assess the various investment packages, MDOT used the REMI Model (Regional Economic Models, Inc.) to evaluate each investment scenario. The simulation capabilities of the REMI Model can be found in a detailed description in **Appendix B**, at the end of this report, and in the *Methodologies of Economic Impacts Report*.

Economic Impacts of the Transportation Investment to Michigan's Economy

The following table summarizes the impacts on Michigan's economy associated with each of the investment packages as compared with a zero-investment scenario over the life of *MI Transportation Plan*. The economic benefits from the "Business as Usual" (BAU) investment package include a $50.0 billion (measured in 2005 dollars or $2005) increase in gross state product (GSP) and $38.4 billion increase in personal income over the period of 2007 to 2030. The BAU package also will add 30,000 permanent full-time equivalent jobs by the year 2030. In addition, Michigan residents will experience benefits from travel time savings realized through the investment to maintain and improve the transportation system. The value of commuting and non-work travel time savings for personal travel can reach $22.2 billion over the lifetime of *MI Transportation Plan*.

The "Change the Mix" package has the same level of investment as the BAU, but will re-allocate funds between programs/modes. As a result, the economic benefits are very similar to the impacts from the BAU package. When re-allocating funds, the "Change the Mix" package will reduce investments in highway programs that alleviate congestion pressure on roadways and result in increased personal travel time. Correspondingly, travel time saving benefits will decrease, though moderately, as compared with the BAU.

Both the "Move Ahead" and the "Flexible New Revenue" packages propose to increase investment funds to expand and improve the transportation services offered by various modes/programs. The economic benefits to Michigan's economy are an additional $8.3 billion

and $18.7 billion in GSP generated in response to the "Move Ahead" and "Flexible New Revenue" packages, respectively, from 2007 to 2030. This represents growth above and beyond the $50 billion increase in GSP for the BAU package.

Based on the impact results estimated for the BAU and three alternative investment packages, MDOT developed a fourth alternative called the "Investing to Achieve the Vision" (IAV) investment package. The IAV proposes investing more funds (about $0.9 billion) than the "Flexible New Revenue" investment package in the preservation and expansion of several transportation modes and programs such as aviation and multi-modal. The IAV package results in economic returns of nearly $70 billion in GSP and over $80 billion in combined personal income and travel time savings from 2007 to 2030. In addition, the IAV package will generate more than 43,000 permanent full-time equivalent jobs by 2030 as compared to a zero-investment forecast.[1] Consequently, the return on investment is $1.64 in economic benefits for Michigan residents for every one dollar invested in transportation.[2]

Notable are the types of jobs that will be supported by the investment in transportation. Excluding construction, the industries projected to benefit the most in terms of employment gains include transportation, warehousing and trade, professional, technical, educational and management services, and tourism industries. This is important because it demonstrates the ability of the transportation plan to support diverse sections of the state's economy. The benefit estimates for these packages should be considered the lower bound of potential benefits because, due to data limitations, the analysis does not fully account for all of the benefits arising from the transportation investments. Specifically, the analysis does not fully capture social and environmental benefits or the full value of logistics cost savings to Michigan businesses, both of which will have positive impacts on the economy.

[1] The economic impact results are also presented in the *Investing to Achieve the Vision Report.*

[2] The economic benefits used for this calculation include Gross State Output and the value of personal time savings.

Economic Impacts of the Investment Packages over the Period 2007-2030

	"Business As Usual" (BAU)	*"Change the Mix"*		*"Move Ahead"*		*"Flexible New Revenue"*		*"Investing to Achieve the Vision"*	
		Cumulative Impact	*Change from BAU*	*Cumulative Impact*	*Change from BAU*	*Cumulative Impact*	*Change from BAU*	*Cumulative Impact*	*Change from BAU*
Total Employment (in thousands of Permanent full-time equivalent jobs)	30	30	0 (0.0%)	36	6 (20.0%)	42	12 (40.0%)	43	13 (43.3%)
Gross State Product (in billions of 2005)	$50.0	$50.1	$0.1 (0.2%)	$58.3	$8.3 (16.6%)	$68.7	$18.7 (37.4%)	$69.6	$19.6 (39.2%)
Personal Income (in billions of 2005)	$38.4	$38.5	$0.1 (0.3%)	$45.1	$6.7 (17.4%)	$53.3	$14.9 (38.8%)	$54.7	$16.3 (42.4%)
Personal Travel Time Savings (in billions of $2005)	$22.2	$21.4	-$0.8 (-3.6%)	$23.4	$1.2 (5.4%)	$27.0	$4.8 (21.6%)	$27.1	$4.9 (22.1%)

Source: Wilbur Smith Associates

Economic Impacts at the Regional Level

To analyze the economic impacts of the investment packages at the regional level, the state of Michigan is divided into 17 study regions.

As shown in the following table, the economic benefits for the period of 2007 to 2030 vary in accordance with the magnitude of the economy in each region. For instance, the Greater Detroit Region (i.e., Region 1B), with nearly 50 percent of the state economy, has the highest impact generated from the IAV. Over the life of *MI Transportation Plan* (from 2007 to 2030), the Greater Detroit Region may see the gross economic benefits of a $42.6 billion (in $2005) increase in Gross Regional Product (GRP), and a $29.5 billion increase in personal income. Compared with the "Business as Usual" package, the IAV generates an additional $11.3 billion in GRP and $8.5 billion in personal income for this region.

Regional Economic Benefits over the Period of 2007 to 2030

		"Business as Usual"				*"Investing to Achieve the Vision"*			
No.	*Region Name*	*Total Emp.*	*GRP*	*Personal Income*	*Personal Time Savings*	*Total Emp.*	*GRP*	*Personal Income*	*Personal Time Savings*
1A	Greater Ann Arbor	15	2.7	2.7	1.4	22	3.9	3.9	1.8
1B	Greater Detroit	157	31.3	21.0	16.3	225	42.6	29.5	18.8
2	Greater Jackson	6	0.8	0.8	0.2	8	1.2	1.2	0.3
3	South Central MI	12	1.5	1.4	0.4	17	2.2	2.0	0.6
4	Greater Benton Harbor	7	0.7	0.7	0.2	10	1.0	1.0	0.3
5	Greater Flint	15	2.1	2.1	0.6	21	3.0	3.0	0.9
6	Greater Lansing	15	2.0	1.7	0.5	22	2.9	2.5	0.7
7A	East Central MI	8	0.7	0.7	0.2	11	1.1	1.1	0.2
7B	Greater Saginaw	14	1.7	1.7	0.4	20	2.4	2.4	0.6
8A	Greater Big Rapids	4	0.5	0.5	0.2	6	0.7	0.7	0.2
8B	Greater Grand Rapids	25	3.7	2.8	1.1	36	5.2	4.1	1.5
9	Northeast Michigan	4	0.4	0.4	0.1	6	0.5	0.5	0.1
10	Northwest Michigan	6	0.7	0.7	0.2	9	1.0	1.0	0.4
11	Eastern Upper Peninsula	2	0.1	0.1	0.0	2	0.2	0.2	0.1
12	Central Upper Peninsula	3	0.3	0.3	0.1	4	0.5	0.4	0.2
13	Western Upper Peninsula	2	0.2	0.2	0.0	3	0.3	0.3	0.0
14	West MI Shoreline	5	0.6	0.6	0.3	8	0.9	0.9	0.4
	Total	300	50.0	38.4	22.2	430	69.6	54.7	27.1

Source: Wilbur Smith Associates

(Employment is in hundreds of full-time equivalent permanent jobs and other indicators are in billions of $2005.)

A detailed background of the methodologies of estimating economic impact results of the investment packages is found in the *Methodologies of Estimating Economic Impacts Report.*

Chapter 1. Introduction

Michigan's transportation system provides the backbone for all economic activities within the state. The transportation system, including roads, transit, non-motorized facilities and inter-modal facilities, plays an integral role in supporting the state's economy and the quality of life for Michigan residents. Transportation investments are part of the state's overall economic development strategy, and MDOT identifies the link between transportation and the economy as their top priority.

An efficient transportation system saves time and money for individuals and businesses, enhancing productivity and competitiveness and promoting economic growth. Statistics indicate that the demand for transportation grows along with economic activities. In the United States (US), transportation is a major component of the economy in terms of gross domestic product (GDP), employment, and expenditure. Transportation is even more important for Michigan given that vehicle manufacturing is Michigan's largest industry.

The demand for the transportation system is now statewide, and has been rising steadily as the economy expands and population decentralizes. It has added tremendous pressure on state government agencies that provide and maintain the major portion of the transportation system. To meet the increasing demands of the transportation sector, government agencies around the US are considering increased investments to build new corridors, add capacity, and/or improve the levels of service for their respective transportation systems. MDOT is also actively taking into consideration means and methods to enhance the state's transportation system in order to accommodate long-term economic growth and future transportation needs in the state.

1.1 Objectives of the Study

The purpose of this report is to examine the potential economic impacts to Michigan's economy when MDOT invests in the improvement and maintenance of the state's transportation system. Specific objectives of this analysis are to:

- Review the *Preferred Vision* and the alternative investment packages in *MI Transportation Plan*. **Chapter 2** provides this review.
- Estimate the economic benefits to Michigan's state economy from the investment packages including "Investing to Achieve the Vision." Findings are presented in **Chapter 3**. (In order to assess the various investment packages, MDOT used the REMI Model to evaluate each investment scenario. The simulation capabilities of the REMI Model can be found in a detailed description in **Appendix B**, at the end of this report, and in the *Methodologies of Economic Impacts Report*.)
- Examine the distribution of potential impacts generated by the investment packages at the regional level. **Chapter 4** presents the regional findings.

- Offer some conclusions based on the economic impact results obtained in this analysis. **Chapter 5** presents the conclusions.

Chapter 2. Investment Packages

The Michigan Department of Transportation, (MDOT) through *MI Transportation Plan,* answered the challenge by proposing and studying a transportation vision that includes investments for preserving, modernizing, and adding capacity to Michigan's transportation system. Michigan's *Preferred Vision* not only lays out actions to be taken to satisfy the future needs in transportation, but also provides the necessary transportation infrastructure and flexibility necessary to bring new economic opportunities to Michigan through enhancing economic competitiveness and diversifying the economic base.

2.1 The Preferred Vision

The *Preferred Vision* of Michigan's transportation system developed for *MI Transportation Plan* requires that the entire system (all modes) be maintained, preserved, and protected as one of the state's most important physical assets.[3]

The *Preferred Vision* is summarized in nine elements that need to be addressed and achieved when implementing *MI Transportation Plan*. These elements are:

- **Purposeful:** Michigan's 2030 integrated transportation system will be the foundation of the state's economic vitality and will sustain quality of life for its residents.
- **Prioritized:** Capacity improvements will be needed, but the first priority will be physical or technological improvements to enhance efficiency, mobility and access.
- **Coordinated:** All transportation providers will work together to address the system's needs holistically. All modes will be maintained, preserved, operated, and protected as one system, one of the state's most important physical assets.
- **Safe:** Safety will be a primary goal. It will be addressed, as each improvement is planned and implemented. Personal and system wide security will be enhanced, including border security.
- **Advanced:** MDOT will embrace technology and technological development. The department will use innovation in every aspect of what it builds, how it builds, and in every service that is provided.
- **Integrated Choices:** System integration will be achieved for both passenger and freight transportation through improvements in modal services and effective intermodal connections. The system will be responsive to the public's demand for more transit, bicycle and pedestrian choices. The need for freight and passenger movement will be balanced, and the system will accommodate both without compromising goals for safety or economic competitiveness.

[3] A more detailed discussion is found in the *2030 Preferred Vision for an Integrated Transportation System Report*.

- **Appropriate to the Setting:** Transportation will be integrated between modes, and also with land use, economic, and environmental systems. Transportation solutions will be regionally sensitive, sustainable, and energy efficient. Infrastructure improvements will be tailored to the community and natural setting and will be planned cooperatively so customers and partners are satisfied with the result.
- **Flexibly-Funded:** Transportation financing will be diversified to include new methods and techniques, but public funds will remain dedicated to transportation purposes. Funding will be flexible so that money can be allocated to meet the highest priority user needs.
- **Responsive:** MDOT will be an open and flexible organization, responsive to customer needs and with a transparent, accountable decision-making process. MDOT will be proactive, adaptable, and able to identify and respond to change as needed.

2.2 Goals of Investment Packages

The ultimate goal of improving and expanding Michigan's current transportation system and further enhancing its multi-modal facilities is to create a seamless transportation network throughout the state for personal travel and commercial transportation. Specific goals of *MI Transportation Plan* summarized in other technical reports include:[4]

- **Stewardship:** Preserve transportation system investments, protect the environment, and utilize public resources in a responsible manner;
- **System Improvement:** Modernize and enhance the transportation system to improve mobility and accessibility;
- **Efficient and Effective Operations:** Improve the efficiency and effectiveness of the transportation system and transportation services and expand MDOT's coordination and collaboration with partners; and
- **Safety and Security:** Continue to improve transportation safety and ensure the security of the transportation system.

To achieve those goals, MDOT is considering different investment options including, but not limited to, increased expenditures for key transportation modes and programs. Modes and programs that may benefit from increased funding include urban freeways, highway pavement reconstruction, intelligent transportation system (ITS), safety, and multi-modal facilities.

2.3 The Four Initial Investment Packages that were Studied

Four long-term transportation investment strategies are considered in *MI Transportation Plan*. These investment packages are referred to as "Business as Usual," "Change the Mix," "Move

[4] As stated in the *Goals, Objectives, and Performance Measures Report* and the *Revenue Gap and Investment Packages Report*.

Ahead," and "Flexible New Revenue." The "Business as Usual" package is the base investment package while the other three represent alternative funding packages.[5]

As the name suggests, the "Business as Usual (BAU)" package represents an investment pattern consistent with historical increases in user fees and an allocation among programs consistent with today's policies. The BAU package foresees a steady increase of state and federal funding for the Michigan transportation system over the life of *MI Transportation Plan,* with the current revenue allocation among programs and modes remaining the same. The total amount of investment for the BAU package is $37 billion (in $2005) over the time period up to 2030. The BAU package will not be able to meet all the future needs for Michigan's transportation system but it assures that the basic needs of the system would be met.

The "Change the Mix" package anticipates the same level of funding for the transportation system as the "Business as Usual" package; however, the allocation of spending is adjusted to increase investment in those programs most consistent with the *Preferred Vision* of *MI Transportation Plan.* In order to invest in programs consistent with the vision, highway preservation investment would need to be reduced below "Business as Usual" levels by $2.8 billion (in $2005) over time and would be reallocated to highway modernization programs including ITS and also to the preservation of multi-modal programs.

The "Move Ahead" package envisions an increase in funding for transportation over the life of *MI Transportation Plan*. These additional funds are over and above the investment assumed for the BAU package for the future development and maintenance of Michigan's transportation system. New investment of $6.2 billion would be allocated among freight, highway preservation, highway modernization, and multi-modal programs. Meanwhile, the "Flexible New Revenue" package foresees adding $15.7 billion to highway expansion and in other transportation modes/programs. For some modes/programs, the increase in investment is significant. For example, the increase for highway pavement construction reaches nearly $6 billion through 2030, which is 10 times higher than the investment for that program in the "Move Ahead" package.

Table 1 illustrates the allocation of the funds for each of these four investment packages. For the "Business as Usual" package, total funds and their allocation are shown for transportation modes and programs. For the other alternative packages, only changes in funds are shown. The values in **Table 1** are all expressed in millions of 2005 dollars over the lifetime of *MI Transportation Plan*. A more detailed explanation of the investment packages is found in the *Revenue Gap and Investment Packages* report.

2.4 Investing to Achieve the Vision

Based on the analysis conducted for the four initial investment packages, MDOT developed an additional investment package for achieving the *Preferred Vision* outlined for the future

[5] Detailed discussion of the investment packages and the allocation of the investment funds are presented in the *Revenue Gap and Investment Packages Report* and the *Investing to Achieve the Vision Report*.

development of Michigan's transportation system. As shown in **Table 1**, the "Investing to Achieve the Vision" (IAV) calls for an increase of $16.5 billion (in $2005) over the "Business as Usual" base investment package during the lifetime of *MI Transportation Plan*.

Table 1: Allocation of Transportation Funds for the Five Investment Packages over the Period of 2007 to 2030 (in millions of $2005)

	Base Package	*Additional Funds for Alternative Packages*			
Mode/Program	***"Business as Usual"***	***"Change The Mix"***	***"Move Ahead"***	***"Flexible New Revenue"***	***"Investing to Achieve the Vision"***
Aviation	2,010				363
Freight	220		50	50	50
Highway Expansion				1,320	1,320
New roads/capacity	206				
Capacity improvement (adding lanes)	2,024				
Subtotal	2,230			1,320	1,320
Highway Preservation					
Pavements Resurfacing	5,773	-866	569	608	608
Pavements Reconstruction	5,411	-812	534	5,720	5,720
Pavements Preventive Maintenance	2,783	-418	275	115	115
Subtotal	13,967	-2,096	1,378	6,443	6,443
Bridge					
Rehabilitation and Replacement	3,409	-510	336	1,572	1,572
Preventative Maintenance & Special Needs	1,007	-151	99	464	464
Big Bridge (all needs)	460	-69	45	211	211
Subtotal	4,876	-730	480	2,247	2,247
Highway Modernization					
Operational Improvement, Safety & ITS	2,666	945	1,051	1,658	1,658
Highway Others					
Borders	2,089				
Other Highway Capital	3,178				
Subtotal	5,267				
Multi-modal Operations					
Transit – Capital	775	254	435	530	530
Transit – Operating	4,611	1,499	2,586	3,153	3,153
Intercity Passenger	365	119	205	250	250
Carpool/Park Lots – Preservation	14	5	8	10	10
Bicycle and Pedestrian Improvement	13	4	7	9	9
Subtotal	5,778	1,881	3,241	3,952	3,952
Multi-modal Expansion					
Transit Expansion					400
Intercity Expansion					89
Carpool/Park Lots – Expansion	17				0
Subtotal	17				489
Grand Total	37,031	0	6,200	15,670	16,522

Source: Wilbur Smith Associates

* There may be small differences between these numbers and those in the *Revenue Gap and Investment Packages* report due to rounding.

Chapter 3. Impacts of the Investment Packages on Michigan's Economy

The evaluation of economic impacts of each investment package relies on the aggregated impacts of potential investments for the various transportation modes and programs. This evaluation differs from traditional analyses for individual transportation projects. At the project level, very detailed and specific information is available about where the project will be and which geographic area will be impacted. Then, the economic impacts generated from a specific transportation project are investigated for defined user groups, and geographic areas. However, at the aggregated program level, detailed information will not be available or easily identified.

Evaluating comprehensive investment packages for transportation improvements, such as those by MDOT, requires special attention to the diversion effects between highway and other transportation modes/programs. The potential traffic diversion from highway to other modes will mitigate congestion on Michigan's roadways and provide benefits to the entire transportation system.

For each alternative investment package presented in **Chapter 2,** the economic impacts on Michigan's economy are evaluated to determine the effects of investment decisions that are different from a zero-investment scenario. **Section 3.2** summarizes the direct economic impacts and also discusses the total economic impacts.

The estimated economic impact results, presented in **Section 3.3**, reveal economic benefits to Michigan's economy, users of the transportation system, and effects of changes or increases in government spending on various transportation modes and programs.[6]

3.1 Investment Impacts on Transportation Modes/Programs

The investment packages examined in this analysis cover a wide range of transportation programs and modes. These include highways, bridges, transit, freight, intercity passenger bus/rail, aviation, border crossings, and bicycle.[7] Also considered in the investment packages are operational and safety improvements, intelligent transportation systems (ITS), and carpool/park and ride lots.

As indicated in the *Highway and Bridge Technical Report*, 38 percent of state-trunkline vehicle miles of travel (VMT) were at or approaching congested in 2004. By 2030, this percentage is forecasted to increase to 55 percent of total VMT. These numbers indicate that there is an existing strain on highway capacity, which can be directly reduced by investment in the

[6] The methods of estimating impacts are presented in detail in the *Methodologies of Estimating Economic Impacts Report.*

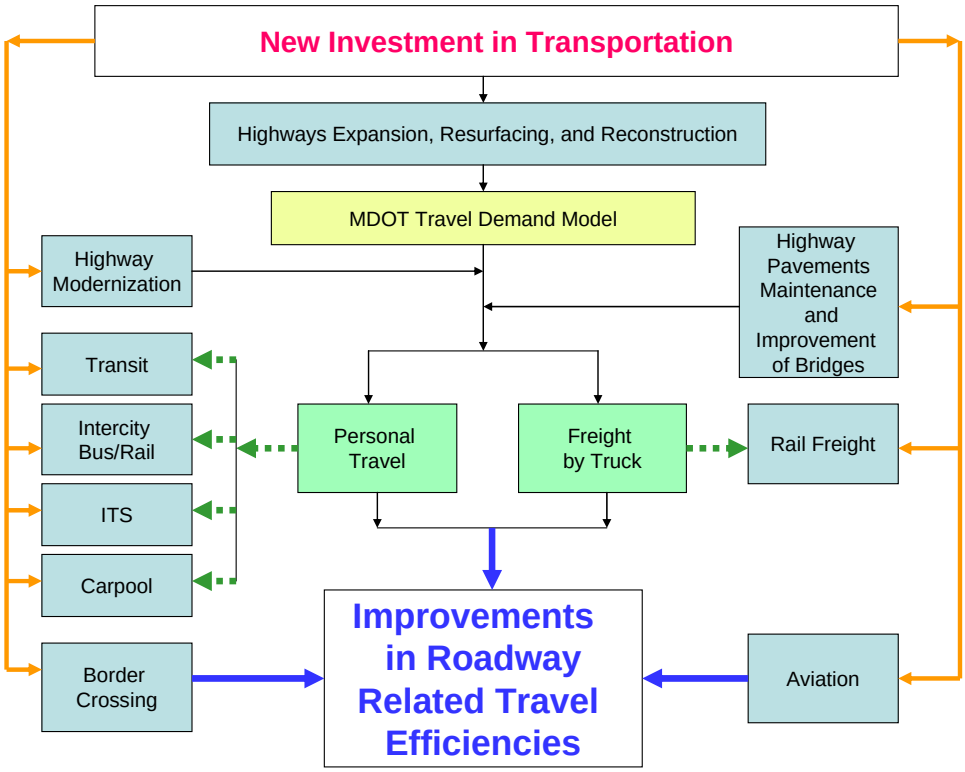
[7] The economic impacts of the improved border crossing and aviation are discussed in **Chapter 5**.

Michigan highway system. In addition, the investment in other transportation modes/programs can also mitigate congestion pressure.

Costs associated with travel time and mileage as measured by vehicle hours of travel (VHT) and VMT are key drivers in determining impacts of the investment on transportation modes/programs within an investment package and in determining economic impacts between alternative investment packages. This section discusses the investment impacts on transportation modes/programs within an investment package, while the economic impacts between alternative investment packages is related in **Section 3.3**.

Figure 1 highlights the interrelationship between the transportation modes. Improvements to highways due to new investment will be captured in VHT and VMT predicted by the MDOT statewide travel demand model. Based on the relationship between transportation modes/programs as established in the existing research and studies, there will be traffic diversion from highways to other modes as a result of the investment. The level of diversion depends on the level of investment for a specific mode/program. To capture the effects of the traffic diversion from highway to other modes, the VHT and VMT estimated from the travel demand model need to be adjusted to reflect the reduction in highway demand.

Figure 1: Investment Impact on Transportation Modes/Programs



Source: Wilbur Smith Associates.

(Note that the dotted arrow lines express the potential diversion from highway to other modes).

3.2 Direct and Total Effects of the Investment Packages

In the previous section, we discussed the adjustment of traffic data to capture diversion effects from highway to other transportation modes. After adjustments, the traffic data associated with the investment packages, including the zero-investment scenario, are ready for economic impact analysis.

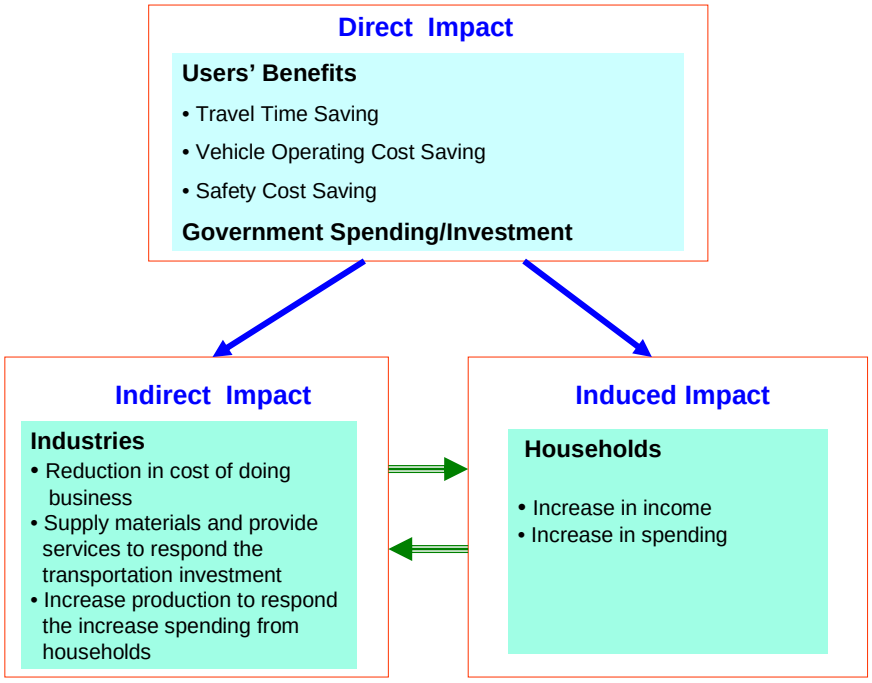
The economic impact analysis intends to estimate the total economic effects, including the direct, indirect, and induced effects, between an investment package and the zero-investment scenario. The direct effects comprise benefits from transportation system users and new government spending. The indirect effects represent additional industrial activities supported by the direct effects, and the induced effects represent the ripple effects arising as spending of increased wages and salaries cycles through the state's economy.

Specific direct effects from transportation system users include travel time savings, vehicle-operating cost savings, and safety cost savings. Travel time savings for business travelers and freight transportation will help businesses reduce costs. Vehicle-operating costs, which include fuel and maintenance, are affected by changes in speed, fuel price, and other factors. These costs have impacts on people's consumption patterns and business operations. If the vehicle-operating costs are reduced, people can spend more money on other products and services, and businesses will realize savings. Less congestion on highways reduces the probability of accidents, which also reduces costs for businesses.[8]

Figure 2 depicts the relationship between the direct economic impact and the indirect and induced impacts and also presents key components associated with each type of impact. The estimation of the direct impacts and the economic model used are described in detail in the *Methodologies of Estimating Economic Impacts Report*.

[8] See the *Methodologies of Estimating Economic Impacts Technical Report* for detailed discussion of w to estimate the direct effects of user's benefits.

Figure 2: Direct, Indirect, and Induced Economic Impacts from the Transportation Investment



Source: Wilbur Smith Associates

3.3 The Economic Impact Results

The estimated economic impact results indicate that the public investment in transportation will not only improve and maintain the transportation system, but also make substantial contributions to Michigan's economy. Though the size of economic impacts depends on the level of investment committed and the amount of investment for each transportation mode/program, the returns on the public investment could be significant.

MDOT's current investment strategy focuses investments on the preservation of the existing transportation system and on the delivery of a limited number of capacity improvement projects. However, the investment program selected for inclusion in this analysis utilized different strategies.

The investment packages were selected in order to maximize the reduction of congestion and delay. These projects are primarily located on high-volume roadways in urbanized areas, representing the very best return of investment, and are in keeping with the high-level analysis being performed for *MI Transportation Plan*.

3.3.1 Impacts of the Four Initial Investment Packages that were Studied

Table 2 summarizes the estimated economic impacts that are generated by the four investment packages. The estimated economic impacts indicate that the investment packages can have positive effects on the Michigan economy over the life of *MI Transportation Plan*.

The economic benefits from the "Business as Usual" (BAU) investment package include a $50.0 billion (in $2005) increase in GSP and a $38.4 increase in personal income over the period of 2007 to 2030. Also, the BAU investment package will add 30,000 permanent full-time equivalent jobs by 2030 (compared to zero investment). In addition, Michigan residents will experience benefits from travel time savings when compared to no public investment to maintain and improve the transportation system. The value of travel time savings from personal travel can reach $22.2 billion over the life of *MI Transportation Plan*.

The "Change the Mix" package has the same level of investment as the BAU package, but will re-allocate funds between programs/modes. As a result, the economic benefits are very similar to the impacts from the BAU package. When re-allocating funds, the "Change the Mix" package will reduce investments in highway programs that will alleviate less congestion pressure on roadways and result in increase in personal travel time. Correspondingly, travel time saving benefits may decrease, though moderately, as compared with the BAU package.

Both the "Move Ahead" and the "Flexible New Revenue" packages propose to increase investment funds to expand and improve the transportation services offered by various modes/programs. As presented in **Table 2**, the GSP will increase by an additional $8 billion and $19 billion for the "Move Ahead" and "Flexible New Revenue" packages, respectively, over the $50 billion increase in GSP for the BAU package. Those increases are more than a 17- and 37-percent increase in GSP, respectively, for the two packages, relative to the BAU package.

3.3.2 Impacts of the "Investing to Achieve the Vision" Package

Table 2 also presents the economic benefits for the IAV and makes a comparison with the impacts from the BAU package. Because the IAV makes more investments than other alternative investment packages studied above, the relative economic impacts are higher than the results from those packages. When compared to a zero-investment forecast the IAV package results in economic returns of nearly $70 billion in gross state product (GSP) and over $80 billion in personal income and travel time savings over the period of 2007 to 2030. In addition, the IAV package will generate more than 43,000 permanent full-time equivalent jobs by 2030. This translates into $1.64 in economic benefits for Michigan residents for every one dollar invested in transportation.[9] In comparison, the Business as Usual program gives rise to nearly $50 billion in economic impacts and nearly 30,000 permanent full-time equivalent jobs.

In terms of job increases, notable are the types of jobs that will be supported by the investment in transportation. Excluding construction, the industries projected to benefit the most in terms

[9] The economic benefits used for this calculation include gross state output benefits and the value of personal time savings.

of employment gains include transportation, warehousing and trade; professional, technical, educational and management services; and tourism industries. This is important because it demonstrates the ability of the balanced transportation plan to support the necessary transitioning of the state's economy. Due to data limitations, the analysis does not fully account for all of the benefits arising from the transportation investments. Specifically, the analysis does not fully capture social and environmental benefits or the full value of logistics cost savings to Michigan businesses, both of which will have positive impacts to the economy.

Table 2: Economic Impacts of the Investment Packages over the Period 2007-2030

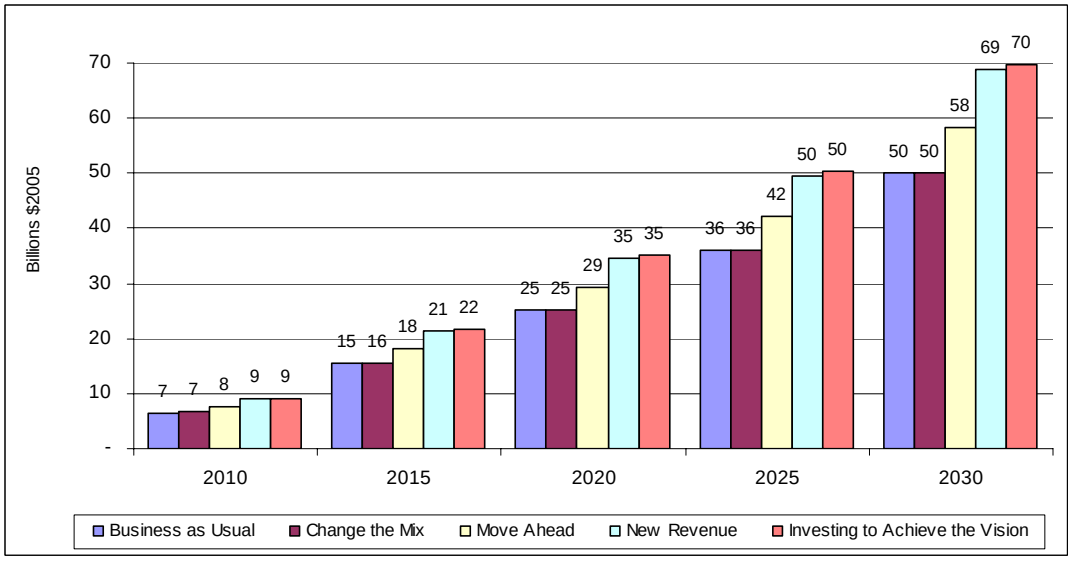
	"Business As Usual" (BAU)	*"Change the Mix"*		*"Move Ahead"*		*"Flexible New Revenue"*		*"Investing to Achieve the Vision"*	
		Cumulative Impact	*Change from BAU*	*Cumulative Impact*	*Change from BAU*	*Cumulative Impact*	*Change from BAU*	*Cumulative Impact*	*Change from BAU*
Total Employment (in thousands of Permanent full-time equivalent jobs)	30	30	0 (0.0%)	36	6 (20.0%)	42	12 (40.0%)	43	13 (43.3%)
Gross State Product (in billions of $2005)	$50.0	$50.1	$0.1 (0.2%)	$58.3	$8.3 (16.6%)	$68.7	$18.7 (37.4%)	$69.6	$19.6 (39.2%)
Personal Income (in billions of $2005)	$38.4	$38.5	$0.1 (0.3%)	$45.1	$6.7 (17.4%)	$53.3	$14.9 (38.8%)	$54.7	$16.3 (42.4%)
Personal Travel Time Savings (in billions of $2005)	$22.2	$21.4	-$0.8 (-3.6%)	$23.4	$1.2 (5.4%)	$27.0	$4.8 (21.6%)	$27.1	$4.9 (22.1%)

Source: Wilbur Smith Associates

Figure 3 demonstrates the cumulative changes in gross state product for the five investment packages at time intervals of five years up to the year 2030. The figure clearly shows that the expected economic benefits increase as public investment increases over time.

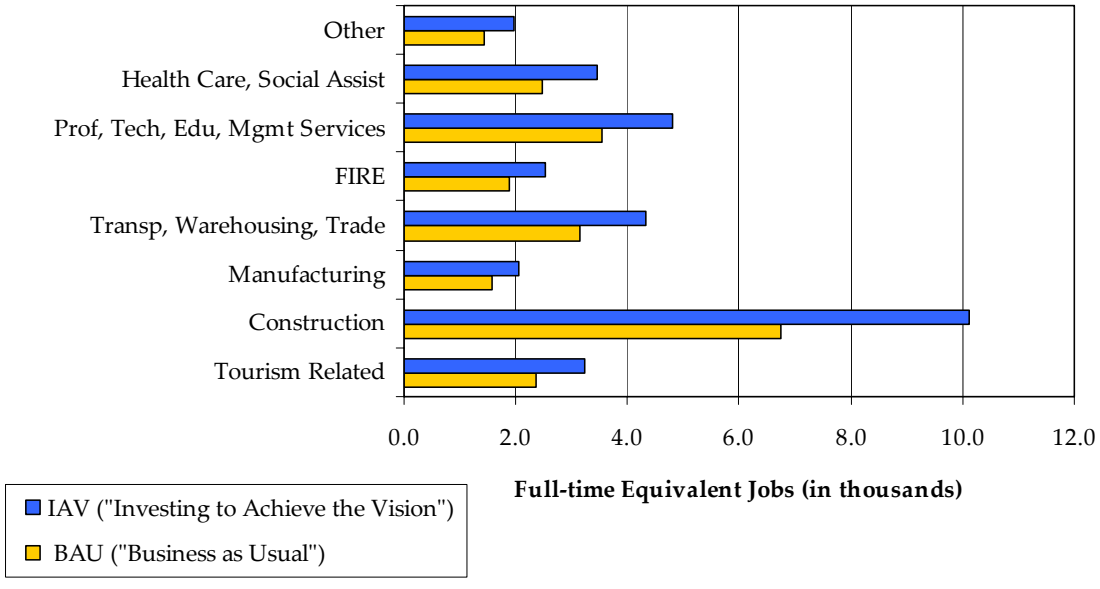
Figure 4 shows a comparison of employment benefits by industry to 2030, between the BAU and IAV. It graphically illustrates the employment advantages of the IAV over the BAU.

Figure 3: Cumulative Changes in Gross State Product for the Five Investment Packages



Source: Wilbur Smith Associates

Figure 4: Employment Benefits by Industry to the Year 2030 IAV Compared with BAU



Source: Wilbur Smith Associates

Note: FIRE = Finance, Insurance, and Real Estate.

3.3.3 Impacts of Border Crossing and Aviation Improvements

This section discusses the economic impacts relating to Michigan's border crossing and aviation improvements. Though both services are part of the transportation system, they are less likely to generate diversion effects. However, the improvements of both services are important to Michigan's economy and deserve special attention for analysis.

The border crossings examined in this analysis are the Ambassador and Blue Water Bridges, as capacity improvement projects have been planned for these two crossings. These improvements will have positive benefits to Michigan's economy. (Analysis of these two border crossings is for a snapshot in time and involved the most current data that was available. Data in other reports may not match due to the ongoing development of each project.) As the cost of doing business for industries in Michigan decreases, and with the potential for increasing spending in Michigan by Canadian visitors after delays at the border crossings are reduced, GSP and personal income will have moderate increases from 2007 through 2030. Investments for border crossings are expected to add $1.6 billion (in 2005 dollars) to GSP and $0.8 billion (in 2005 dollars) to Michigan's economy.

It is worth noting that the positive economic benefits can only be obtained if the conditions of the border crossings are improved. These economic benefits include but are not limited to reduction in freight and passenger travel time, reductions in the costs of conducting business, congestion mitigation, and capacity improvements that could entice border crossing users to relocate to Michigan. If border improvements in Michigan are not implemented commensurately with alternative border crossings outside Michigan, then businesses dependent on international trade may relocate to other states with better border crossings, giving rise to an out-migration of jobs and population.

The economic impact results for the aviation improvements in the initial four investment packages will increase Michigan's GSP by $0.7 billion (in 2005 dollars) and personal income by $0.4 billion (in 2005 dollars) over the period of 2007 to 2030. Since specific improvements associated with the IAV investment package are unknown, an analysis of the additional investment could not be performed.

Chapter 4. Regional Economic Impact Analysis of "Investing to Achieve the Vision"

This chapter presents the economic impact analysis of the IAV at the regional level. It begins with the definition of the study regions and follows with a discussion of regional economic profiles and key industries in Michigan. The economic impacts for the study regions over the life of *MI Transportation Plan* are also presented.

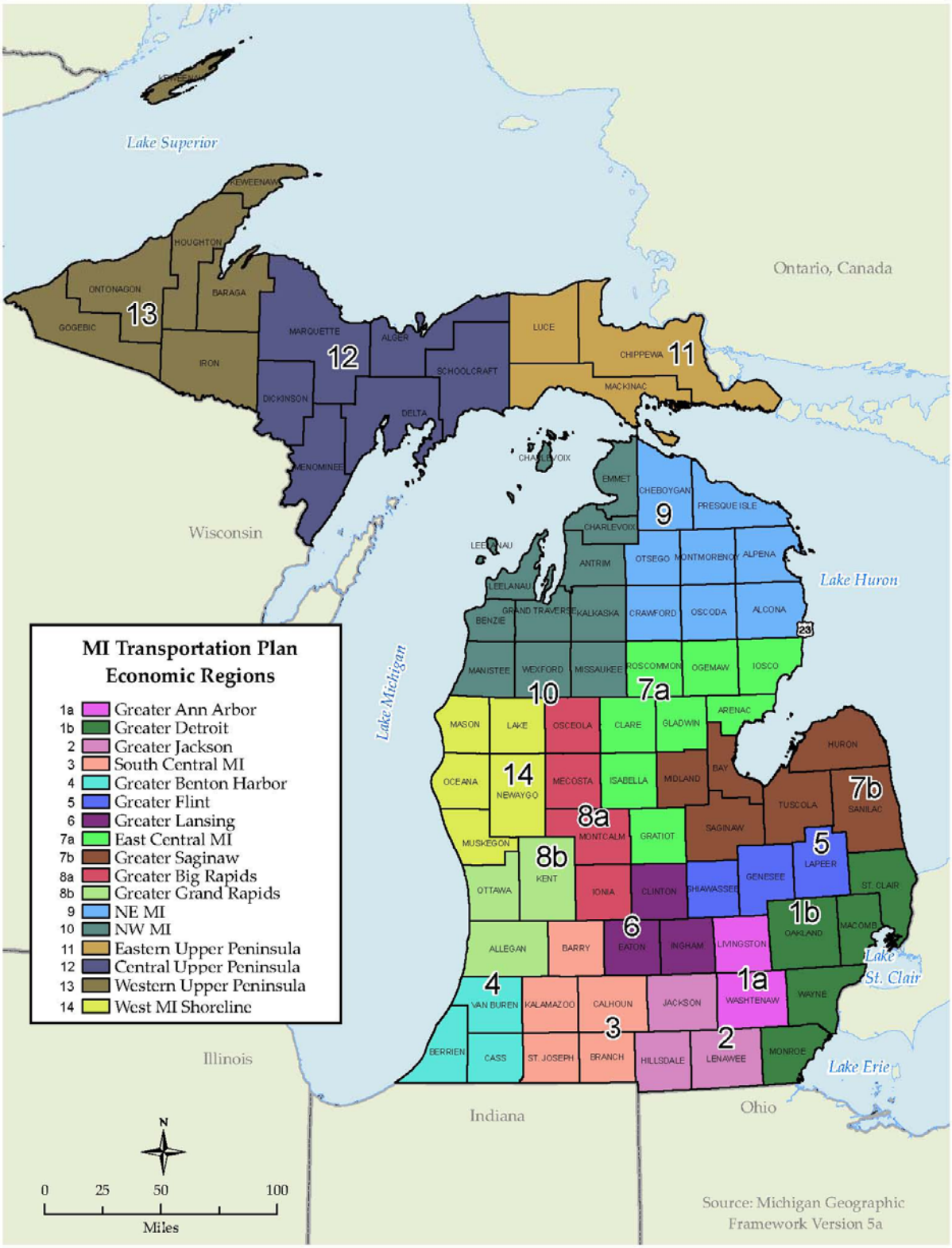
4.1 Definition of the Study Regions

The definition of the study regions is an important step for the economic analysis. The economic analysis intends to examine the impacts of the IAV at the study region level. The IAV and other investment packages have been analyzed at the state level and the economic impact results have been reported in **Chapter 3**.

Several criteria are considered for defining the study regions. These include specifying study regions based on areas defined as state planning and development regions, areas surrounding major cities, areas along major corridors, and areas enclosing metropolitan planning organizations, or existing MDOT regions. After evaluating these criteria, the study planning regions were selected.

After selecting a base for defining the study regions, adjustments to the state planning and development scheme was made to separate major cities such as Detroit and Ann Arbor into two individual areas. As a result, study planning Region 1 (Southeast Michigan Council of Governments) was split into two study regions – Regions 1A and 1B. While Region 1A covers the Greater Ann Arbor area, Region 1B encompasses the city of Detroit with five surrounding counties. Similar adjustments were made for study planning Regions 7 and 8, which then became Regions 7A, 7B, 8A, and 8B. The final number of economic study regions is 17 for the state of Michigan. **Figure 5** shows a map of the economic study regions.

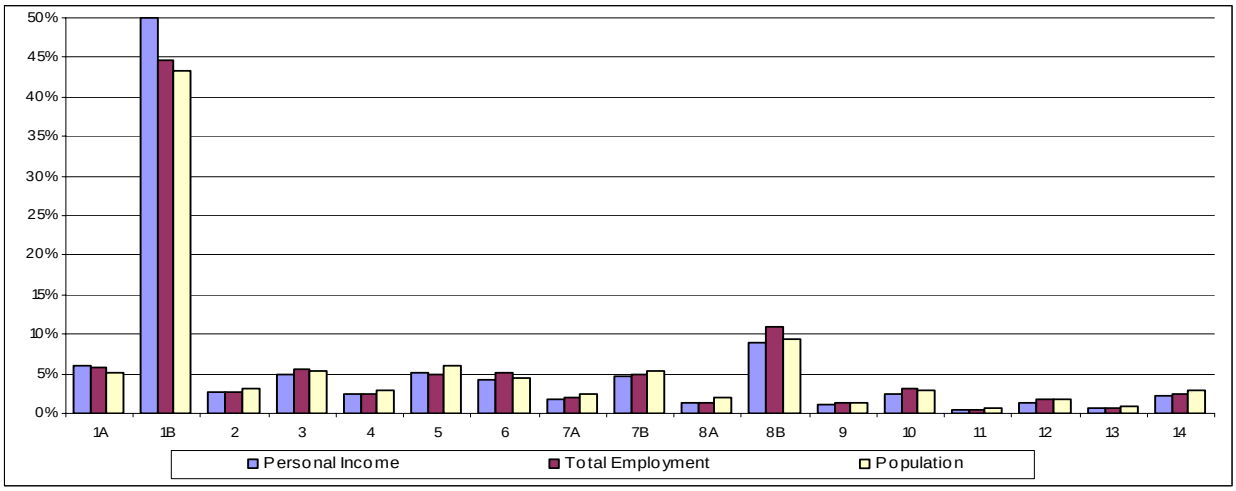
Figure 5: Map of the 17 Michigan Study Regions



Within the state of Michigan, economic conditions, population density, and business concentration vary considerably and resulting demand for transportation services varies. As shown in **Figure 6**, a high concentration of population and job opportunities in Detroit and the surrounding areas makes the city significantly different from any other area within the state. Though other areas show lower concentration than Detroit in terms of population and employment, the economic conditions vary for each area.

As illustrated in **Figure 6** nearly 44 percent of Michigan's population lives in and more than 45 percent of the total jobs in Michigan are also located in the Greater Detroit Region (i.e., Region 1B). Because of high-paying manufacturing jobs concentrated in that area, more than 50 percent of Michigan's total personal income is earned by people living in the Greater Detroit Region. Only one other region, Region 8B (or the Greater Grand Rapids Economic Region), has more than 10 percent of the total jobs in Michigan. All other economic study regions represent around five percent or below of the statewide totals in each of three economic indicators – personal income, employment, and population.

Figure 6: Distribution of Personal Income, Total Employment, and Population among the 17 Study Regions for 2003

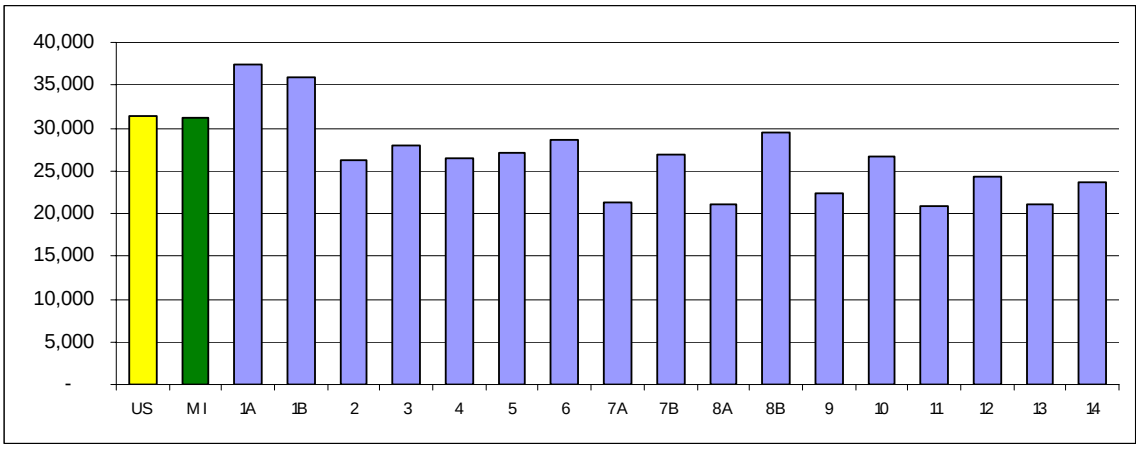


Source: The REMI Model

(Regions 1A=Greater Ann Arbor, 1B=Greater Detroit, 2=Greater Jackson, 3=South Central MI, 4=Greater Benton Harbor, 5=Greater Flint, 6=Greater Lansing, 7A=East Central MI, 7B=Greater Saginaw, 8A=Greater Big Rapids, 8B=Greater Grand Rapids, 9=Northeast MI, 10=Northwest MI, 11=Eastern Upper Peninsula, 12=Central Upper Peninsula, 13=Western Upper Peninsula, and 14=West MI Shoreline)

The per capita personal income for the state of Michigan as a whole was almost the same as the US average ($31,472) in 2003 (the latest year for which data was available). As shown in **Figure 7**, the per capita personal income for the Greater Detroit and Greater Ann Arbor Economic Regions (i.e., Regions 1B and 1A) exceed the US average and reach $35,935 and $37,488, respectively. The per capita personal income for the Greater Grand Rapids economic Region (i.e., Region 8B) was $29,569 in 2003, just behind the US average.

Figure 7: Per Capita Personal Income for the US, Michigan, and the 17 Study Regions for 2003



Source: The REMI Model

(Regions 1A=Greater Ann Arbor, 1B=Greater Detroit, 2=Greater Jackson, 3=South Central MI, 4=Greater Benton Harbor, 5=Greater Flint, 6=Greater Lansing, 7A=East Central MI, 7B=Greater Saginaw, 8A=Greater Big Rapids, 8B=Greater Grand Rapids, 9=Northeast MI, 10=Northwest MI, 11=Eastern Upper Peninsula, 12=Central Upper Peninsula, 13=Western Upper Peninsula, and 14=West MI Shoreline)

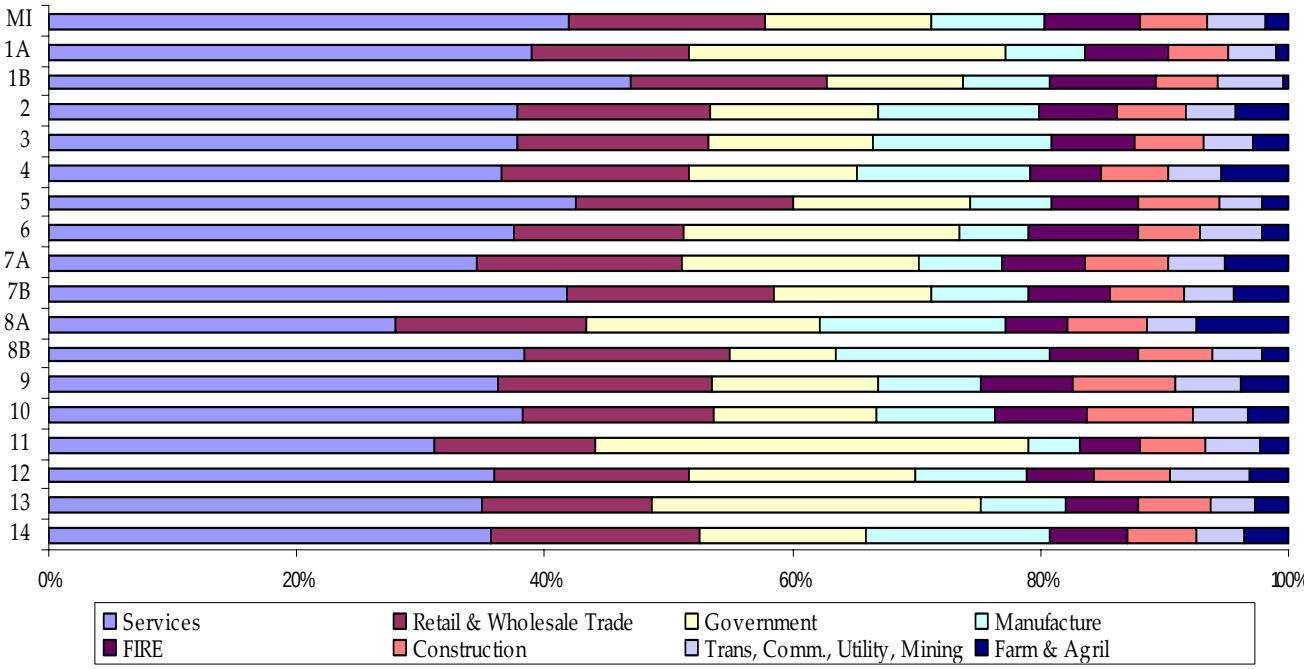
4.2 Key Industries

This section explores the study regions in terms of industrial employment and output.

4.2.1 Employment Distribution

Figure 8 illustrates the distribution of eight aggregated employment sectors by study region for 2003, the latest historical year regional economic data is available with detailed sector information for this analysis. It is clear that the service industry is the leading industry in employment, offering more jobs than other sectors within all the study regions. Approximately 40 percent of total employment across all regions is associated with the service sector. Other industries following behind the service industry are retail trade, state and local government, university employees, manufacturing, and the FIRE (finance, insurance, and real estate) sector.

Figure 8: Distribution of Industrial Employment for the Study Regions



Source: The REMI Model

(Regions 1A=Greater Ann Arbor, 1B=Greater Detroit, 2=Greater Jackson, 3=South Central MI, 4=Greater Benton Harbor, 5=Greater Flint, 6=Greater Lansing, 7A=East Central MI, 7B=Greater Saginaw, 8A=Greater Big Rapids, 8B=Greater Grand Rapids, 9=Northeast MI, 10=Northwest MI, 11=Eastern Upper Peninsula, 12=Central Upper Peninsula, 13=Western Upper Peninsula, and 14=West MI Shoreline)

4.2.2 Number One Industry in the Study Regions

The analysis presented in the last section indicates that the service sector is the number one industry in terms of employment across all study regions. In addition, the auto and manufacturing industries make considerable contributions to Michigan's economy. In this section, the analysis is expanded to include detailed sectors – 66 private non-farming industries – that are then compared for total employment and industrial output for each of the study regions. **Table 3** presents the number one industry in terms of those two economic indicators for each region.

At the disaggregated industry level, the retail trade sector becomes the number one industry in terms of employment for nine regions and the state. In the other eight regions, the state and local government employs more people than all other sectors. The state and local government sector (which includes university employment) in the Greater Ann Arbor Economic Region employs more than 72,000, the highest among those eight regions.

Except in five regions, the auto industry produces more than any other sector. In the Greater Detroit Economic Region alone, the auto industry generated $90 billion in industrial output in 2003. Three other regions – Greater Flint, Ann Arbor, and Grand Rapids – are distant runners-

up to Detroit, as the auto industry in each of those three regions generates about $10 billion output.

Table 3: No. 1 Industry in Each Region in 2003 in terms of Total Employment and Industrial Output

Region		*Total Employment*		*Industrial Output*	
No.	*Name*	*Industry*	*(thousands)*	*Industry*	*(billion $)*
1A	Greater Ann Arbor	S&L Gov't	72	Auto	9.4
1B	Greater Detroit	Retail	260	Auto	89.9
2	Greater Jackson	Retail	18	Auto	2.3
3	South Central MI	Retail	37	Auto	6.4
4	Greater Benton Harbor	S&L Gov't	16	Auto	2.5
5	Greater Flint	Retail	35	Auto	10.4
6	Greater Lansing	S&L Gov't	56	Auto	5.7
7A	East Central MI	S&L Gov't	20	Retail	0.7
7B	Greater Saginaw	Retail	36	Auto	7.4
8A	Greater Big Rapids	S&L Gov't	13	Auto	1.4
8B	Greater Grand Rapids	Retail	66	Auto	9.2
9	Northeast MI	Retail	10	Retail	0.5
10	Northwest MI	Retail	23	Retail	1.3
11	Eastern Upper Peninsula	S&L Gov't	9	Retail	0.2
12	Central Upper Peninsula	S&L Gov't	15	Auto	0.6
13	Western Upper Peninsula	S&L Gov't	10	Retail	0.2
14	West Michigan Shoreline	Retail	19	Auto	1.8
	State	**Retail**	629	**Auto**	149.7

Source: The REMI Model

Note: S&L Gov't - State and Local Government

4.3 Population and Employment Forecast

The forecasts shown in **Table 4** indicate population and employment changes among regions. Eleven of the 17 regions are expected to have double-digit percentage increases in employment from 2005 to 2030. For the Greater Detroit Region, the increase in employment in 2030 is only expected to be 5.9-percent higher than in 2005. In addition, the Greater Detroit Region expects to have a moderate increase of 5.2 percent in population. In contrast, the Greater Ann Arbor Region is expected to increase more than 37 percent in population and 22 percent in employment. Greater Grand Rapids and Northwest Michigan (i.e., Regions 8B and 10) also represent high growth regions; increases in population and employment of more than 24 percent are projected for both.

In some regions, such as those in the Upper Peninsula, the increase in population is expected to be outpaced by an increase in employment. For instance, the Eastern Upper Peninsula Region is expected to have a 6.6-percent increase in population between 2005 and 2030, and an expected increase in employment of 12.7 percent. In 2030, the forecasts indicate that the population in the

state of Michigan will reach 11 million while the total employment will be more than six million.

Table 4: Regional Forecast for Population and Employment

Region		*Population (thousands)*		*Total Employment (thousands)*	
No.	*Name*	*2030*	*% Increase from 2005*	*2030*	*% Increase from 2005*
1A	Greater Ann Arbor	726	37.1	388	22.1
1B	Greater Detroit	4,595	5.2	2,571	5.9
2	Greater Jackson	349	10.7	164	9.1
3	South Central MI	619	11.6	347	10.4
4	Greater Benton Harbor	321	9.3	149	7.2
5	Greater Flint	668	9.0	310	8.5
6	Greater Lansing	527	15.0	344	18.8
7A	East Central MI	283	8.0	139	13.0
7B	Greater Saginaw	574	6.1	299	5.3
8A	Greater Big Rapids	210	7.7	85	8.7
8B	Greater Grand Rapids	1,244	26.9	813	24.7
9	Northeast MI	158	7.5	79	11.3
10	Northwest MI	383	25.4	225	24.4
11	Eastern Upper Peninsula	61	6.6	34	12.7
12	Central Upper Peninsula	180	4.1	106	11.2
13	Western Upper Peninsula	87	3.1	47	12.1
14	West Michigan Shoreline	339	14.5	147	11.1
	State Total	11,326	11.3	6,170	11.3

Source: Michigan Department of Transportation

4.4 Investing to Achieve the Vision

The analysis of the key industries for the economic study regions as shown in the previous section reveals that the auto industry plays an important role in Michigan's regional economies. The auto industry is one of the industries that demands extensive freight transportation and requires the support of Michigan's transportation system. One of the objectives of the IAV investment package is to provide the best and most efficient transportation facilities for Michigan's businesses. This section begins with the regionalization of the IAV and then follows with the presentation of the regional impact results.

4.4.1 Regionalization of the IAV

To conduct an economic analysis for the IAV at the regional level, investment and funding must be distributed to the 17 study regions. This process is called regionalization of the IAV. The regionalization process proves to be difficult because of many unknown factors. For instance, the state can budget certain funds each year dedicated for the purpose of improving or

maintaining certain transportation programs and modes. The amount of investment budgeted for each program/mode is based on historical data. At the regional level, the allocation of investments depends on specific projects and applications. However, future projects and the application of funding are unknown and difficult to predict.

Based on professional knowledge and existing historical data, MDOT staff provided data for transportation programs and modes that are used for regionalizing the IAV. The *Methodologies of Estimating Economic Impacts Report* of *MI Transportation Plan* documents the specific assumptions and methods for this process.

The data provided indicate how investment in programs/modes at the state level could be distributed to each of the 17 regions. The following is an example of how a program might be distributed. The future needs of investment in rail freight consist of three components: investment in the Detroit Intermodal Freight Terminal (DIFT) and Detroit/Wayne County Port Authority (D/WCPA); investment in state-owned rail lines; and investment in the Freight Economic Development Program (FEDP) and the Michigan Rail Loan Assistance Program (MiRLAP). It is easy to determine the regional allocation of DIFT and D/WCPA because they are entirely dedicated to Region 1B (i.e., Greater Detroit Region). The regional allocation for the other two components results in a challenge because state-owned rail lines run across seven regions, and FEDP and MiRLAP are application-based assistance programs. After considering several different methods, the final approach is to use mileage of state-owned rail lines to distribute those two programs.

Once the IAV is regionalized, a similar approach to the one used at the state level is applied to each of the 17 regions. MDOT provides traffic data such as VHT and VMT for the study regions that are used for calculation of user benefits. Also, before the regional economic impacts are estimated, the VHT and VMT data are adjusted to capture the potential traffic diversion effects from roadways to other modes.

4.4.2 Economic Impact of the IAV

Table 5 presents the total economic impacts of the IAV for each of the 17 study regions in comparison with the "Business as Usual" investment package. A region with higher concentrations of businesses and population is expected to have bigger impacts. The Greater Detroit Region (i.e., Region 1B), with about 50 percent of the state economy, has the highest impact generated from the IAV. Over the life of *MI Transportation Plan* (from 2007 to 2030), the Greater Detroit Region may see the economic benefits of $42.6 billion (in $2005) increase in GRP, and $29.5 billion increase in personal income. Compared to the "Business as Usual" package, the IAV generates an additional $11.3 billion in GRP and $8.5 billion in personal income.

The regional economic benefits of the IAV range from $0.2 to $42.6 billion in GRP, $0.2 to $29.5 billion in personal income, and less than $0.01 to $18.8 billion in personal travel time savings among the 17 study regions over the period of 2007 to 2030. The impacts of the IAV on employment range from 200 to 22,500 permanent full-time equivalent jobs among the study regions by the year 2030. The regional analysis indicates that all regions in the state stand to

gain in terms of economic growth and expansion for the transportation investments under the IAV.

Table 5: Regional Economic Benefits over the Period of 2007 to 2030

		"Business as Usual"				*"Investing to Achieve the Vision"*			
No.	*Region Name*	*Total Emp.*	*GRP*	*Personal Income*	*Personal Time Saving*	*Total Emp.*	*GRP*	*Personal Income*	*Personal Time Saving*
1A	Greater Ann Arbor	15	2.7	2.7	1.4	22	3.9	3.9	1.8
1B	Greater Detroit	157	31.3	21.0	16.3	225	42.6	29.5	18.8
2	Greater Jackson	6	0.8	0.8	0.2	8	1.2	1.2	0.3
3	South Central MI	12	1.5	1.4	0.4	17	2.2	2.0	0.6
4	Greater Benton Harbor	7	0.7	0.7	0.2	10	1.0	1.0	0.3
5	Greater Flint	15	2.1	2.1	0.6	21	3.0	3.0	0.9
6	Greater Lansing	15	2.0	1.7	0.5	22	2.9	2.5	0.7
7A	East Central MI	8	0.7	0.7	0.2	11	1.1	1.1	0.2
7B	Greater Saginaw	14	1.7	1.7	0.4	20	2.4	2.4	0.6
8A	Greater Big Rapids	4	0.5	0.5	0.2	6	0.7	0.7	0.2
8B	Greater Grand Rapids	25	3.7	2.8	1.1	36	5.2	4.1	1.5
9	Northeast Michigan	4	0.4	0.4	0.1	6	0.5	0.5	0.1
10	Northwest Michigan	6	0.7	0.7	0.2	9	1.0	1.0	0.4
11	Eastern Upper Peninsula	2	0.1	0.1	0.0	2	0.2	0.2	0.1
12	Central Upper Peninsula	3	0.3	0.3	0.1	4	0.5	0.4	0.2
13	Western Upper Peninsula	2	0.2	0.2	0.0	3	0.3	0.3	0.0
14	West MI Shoreline	5	0.6	0.6	0.3	8	0.9	0.9	0.4
	State Total	300	50.0	38.4	22.2	430	69.6	54.7	27.1

Source: Wilbur Smith Associates

(Employment is in hundreds of permanent full-time equivalent jobs and other indicators are in billions of $2005).

Chapter 5. Conclusions

To achieve the *Preferred Vision* developed for *MI Transportation Plan*, MDOT plans to make substantial investments to improve and maintain Michigan's transportation system. The examination of the economic impacts for the investments in the IAV and other investment packages reveals positive effects on the economy.

- Based on the estimated economic impact results, some conclusions are made regarding benefits from the investment packages:
- *Improving Travel Efficiencies.* As a result of the investments in Michigan's roadways and other transportation modes, the congestion on roadways is expected to be reduced and the travel efficiencies are expected to be improved. Michigan residents and businesses will benefit from travel cost savings through the reduced travel time, safety costs, and vehicle-operating costs. The estimated personal travel time savings for the IAV package is expected to reach $27 billion (in $2005) over the life of *MI Transportation Plan*.
- *Improving Michigan's Economic Vitality*. The economic impact analysis shows that Michigan is expected to create more economic opportunities and gain jobs, while citizens are expected to gain personal income. As the estimated economic impacts indicate, the IAV package is expected to generate economic returns of nearly $70 billion in gross state product and $55 billion in personal income over the period of 2007 to 2030. The IAV will also generate more than 43,000 permanent full-time equivalent jobs when compared to a zero-investment through 2030.
- *Positive Return of the Public Investment*. As estimated, the economic return from the IAV package is $1.64 for every one dollar invested in transportation.
- *Improving Border Crossing and Aviation*. The improvements to border crossing and aviation services as a result of investment are also expected to benefit Michigan's economy. The combined contribution from the improved services is expected to be more than $2 billion in gross state product and over $1 billion in personal income over the period of 2007 to 2030.
- *Increasing Regional Economic Opportunity*. The investments in transportation will also create economic opportunity at the regional level. The Greater Detroit Economic Region will see a nearly $43 billion (in $2005) increase in gross regional product and a $30 billion increase in personal income over the period of 2007 to 2030.

Investment in the transportation system is vital for improving travel conditions, providing safe and efficient transportation infrastructure for Michigan residents and businesses, and creating sustainable economic opportunities for Michigan's economy moving forward.

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Appendix B: REMI Model Structure

This appendix provides a detailed description of the REMI Model developed by Regional Economic Models, Inc., which was selected by MDOT as the tool for performing the comparative economic analyses of the different investment packages.

Compared with other economic tools, the REMI Model is widely recognized for its high level of sophistication and complexity. The model is also recognized for its unique simulation capability that no other model can match.

The REMI Model meshes together and builds on three types of modeling techniques – input-output modeling, econometric modeling techniques, and the concepts of computable general equilibrium (CGE) modeling.

Similar to many other economic models, the regionalized input-output framework plays a critical role in the REMI Model by describing inter-industry relationships and the interaction between final demand and industries. REMI also applies econometric techniques to build several key equations such as the economic-migration equation and the investment equation. Once those equations are estimated econometrically outside of the model, they are inserted into the model structure and linked with the rest of the model.

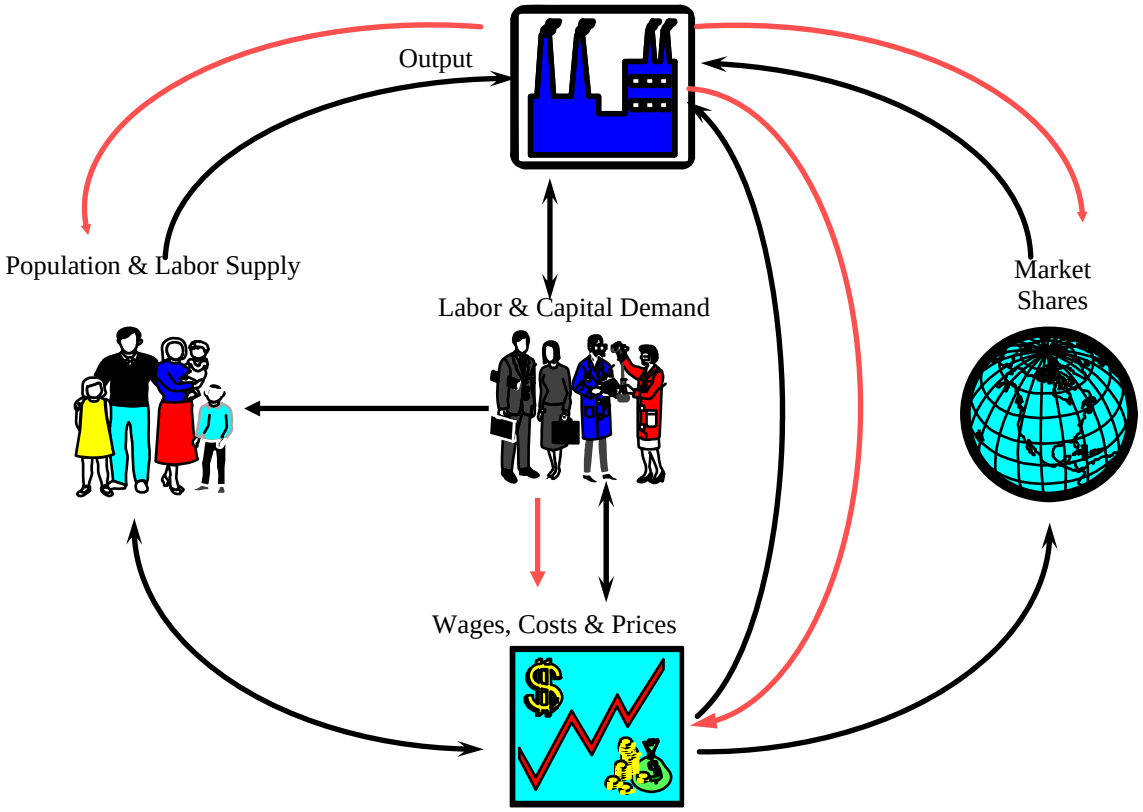
While endogenous final demand and the inclusion of price-responsive products that factor supply and demand endow the REMI Model with desirable features of other CGE models, the REMI Model is not required to reach equilibrium on a yearly basis for all the markets, which is a strict requirement in other CGE models. This allows REMI to incorporate the simulation capabilities of CGE models without being subject to the simplifying assumptions often required to calibrate a CGE model.

The fundamental structure of the REMI Model incorporates detailed inter-industry transactions of intermediate goods in the production process, and interrelated final demand feedbacks that capture the dynamic relationship between income and spending. The model includes several key features, such as substitution among factors of production – for instance, labor and capital – in response to changes in relative factor costs; worker and business migration in response to changes in expected income; wage changes in response to shifts in labor market conditions; and changes in the share of local and export markets in response to shifts in regional profitability and production costs.

As shown in the figure on the next page, a broad view of the structure of the REMI Model is described in five major interrelated blocks in an economy – industrial output; population and labor supply; labor and capital demand; wages, costs and prices; and market shares. The figure illustrates the relationship between the five blocks. For instance, the interaction between the labor demand (from the labor and capital demand block) and the labor supply (in the population and labor supply block) determines wages, which may affect industrial output and market shares.

The figure on the next page extends the broad view of the five blocks presented in the figure below and provides a more detailed illustration of the underlying structure of the REMI Model. Each block contains several major components and the lines and arrows represent their interdependent relationships in the model. The figure can aid the model users to understand the linkage and flow of the model. That is important for users conducting policy simulations. The users can trace the changes that occur within the simulation as a component in the model is affected by a policy. For instance, if a government agency decides to increase spending, the initial component affected in the model will be the state and local government spending. The increase in government spending will have a direct impact on industrial output and subsequently on employment. The users can follow the chart to trace additional responses the model may have. A full technical presentation of the model structure is found in a paper published in the International Regional Science Review.[10]

Five Building Blocks in the REMI Model



Source: Regional Economic Models, Inc.

The REMI Model is appropriate for analyzing the regional economic impacts of the investment packages recommended for future transportation improvements in Michigan. Investment in

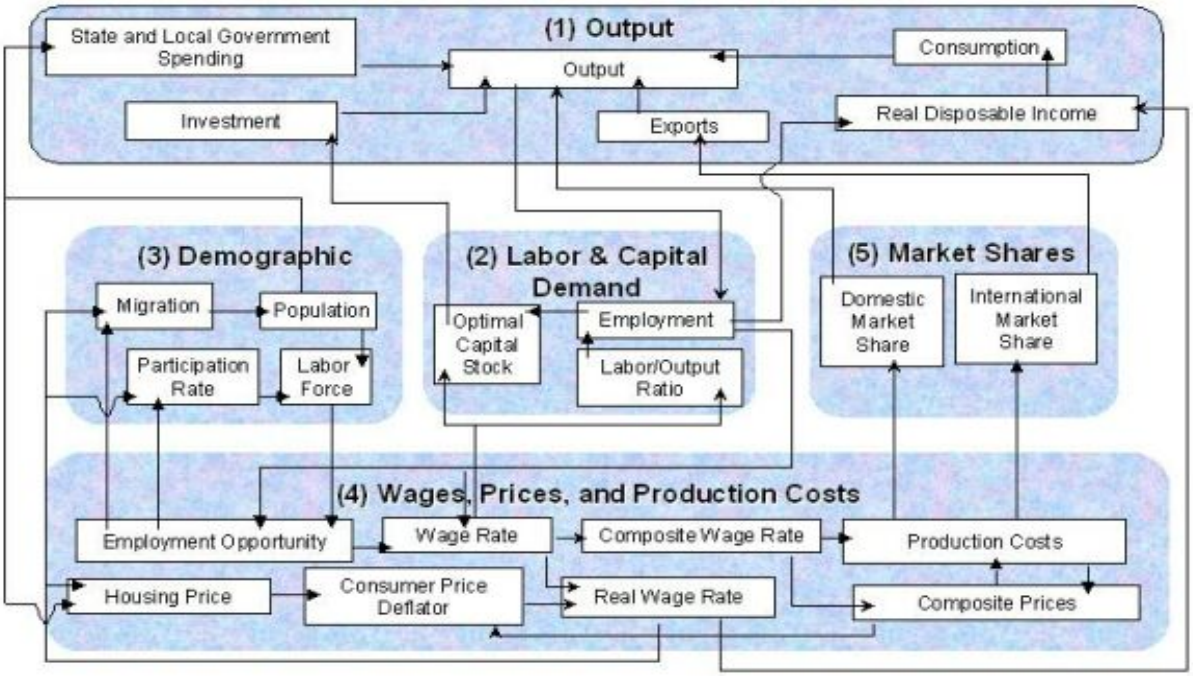
[10] "The REMI Economic-Demographic Forecasting and Simulation Model," George Treyz, Dan Rickman, and Gang Shao, *International Regional Science Review*, 1992, 14(3), 221-253.

transportation will affect the model in several ways. For instance, highway spending will affect the government spending in the output block, while transportation cost savings for business will affect the cost of doing business in the wages, costs, and prices block.

Furthermore, the economic relationships represented in the REMI Model can capture the indirect and induced effects on regional economies resulting from the direct effects realized from travel efficiencies and other direct benefits realized from transportation investments. Travel efficiencies are the benefits that accrue to transportation users measured in terms of reduced travel time, vehicle operating costs, safety costs, emissions, and border crossing and aviation delays. The indirect impacts are the changes in inter-industry purchases of intermediate goods as economic agents respond to the changes in output of major industries due to changes that may result from transportation improvements. For example, reductions in the costs of doing business in Michigan due to travel time savings may have both direct effects on the businesses enjoying the travel time savings, and indirect effects on related businesses and activities.

The induced effects represent the broader implications of a proposed change for households' income and spending patterns. These effects are intended to capture the purchasing decisions made by the employees of industries that are both directly and indirectly affected by the changes in the local economy. The results of indirect and induced economic changes created by the direct effects are generally referred to as multiplier effects.

Economic and Demographic Relationships Within the REMI Model



Source: Regional Economic Models, Inc.

Simulation Capability

The reason that the REMI Model stands out among other regional economic modeling systems is due mainly to its simulation capability. The REMI Model is capable of providing long-range forecasts and simulations. Through simulation, the model helps policy makers and the general public understand economic impacts for many hypothetical scenarios that may arise from changes to Michigan's transportation system.

The default forecasts up to the year 2050 provided by the REMI Model are the model's baseline forecasts. The model also provides thousands of policy variables for introducing changes in the economy due to transportation improvements. Examples of policy variables are:

- Industry output – Locally produced products by industry;
- Industry demand – Demand for industrial products; some of the products are produced locally while others are imported;
- Consumer spending – Personal consumption by spending category;
- Government spending – State and local government spending;
- Investment spending – Investment in residential and non-residential structures and producers' equipments;
- Personal income – Including proprietors' income, transfer payments, social security contributions, dividends, interest, rent, residence adjustments, and personal income taxes;
- Employment – Employment by industry;
- Production costs – Costs of doing business by industry;
- Prices – Consumer prices by personal consumption category; and
- Wages – Compensation by industry.

Typically, the changes introduced into the REMI Model are recognized as direct economic impacts due to government policies or investments in infrastructure such as highway systems. Once these policies and investments are quantified and translated into inputs for REMI Model variables, a simulated forecast is generated. The difference between the simulated forecast and default forecast reflects the total economic impacts to the study region, which include the indirect and induced effects. Because the REMI Model is built on structural form rather than reduced form, the simulated economic impacts are traceable and detectable.[11]

[11] In economics, the reduced form of an economic model is one where each dependent variable is on the left side and all independent variables are on the right side of the equations. Contrarily, the structural form of an economic model is one where all of the equations are specified in terms of economic theory and dependent variables can appear on the right side of the equations.

Data Sources

To build its economic model, REMI has utilized data available from public sources. REMI uses the employment data by industry and region, compensation by industry and region, and personal income by region from the US Commerce Department's Bureau of Economic Analysis and the Department of Labor's Bureau of Labor Statistics (BLS). For population, REMI uses data from the US Census Bureau, while national input-output accounts from BLS are used to derive inter-industry production relationships. REMI updates their historical database once new data becomes available from the aforementioned government agencies.

The REMI Model can be built for a single county or any combination of counties within a state or several states. To examine the economic impact of transportation-related issues for Michigan, the model MDOT acquired has divided the state into 17 study regions. The classification of the study regions follows the scheme of Michigan's State Planning and Development Regions, with some modifications.

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