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Table of Contents

An Exploration into Recent Input-Output Multiplier Innovations
Dennis P. Robinson and Tina Tian 1
(see the companion PowerPoint presentation)

Measuring University Contributions to Regional Economies: A Discussion of Guidelines for Enhancing Credibility
Dave Swenson 13
(see the companion PowerPoint presentation)

The Settlement of San Francisco and the Land Use Changes in the Fan Francisco Bay Area
Nelly Bourlion 34
(see the companion PowerPoint presentation)

Is Irrigated Rice Cultivation Sustainable in Kurunegala District of Sri Lanka
Janaranjana Herath and *Samia Bashir* 54

An Examination of Short-Run and Long-Run Factors Affecting Regional Income Inequality in the United States
Orley O. Amos, Jr. 63

An Analysis of Home Mortgage Foreclosures in Sioux Falls, South Dakota
David Sorenson, Andrew Doshier, Reynold Nesiba, and Kaleb Sturm 80

Economic Multipliers in Local Colorado Economies: The Merits of and Procedures for Including Construction and Local Government Spending in Input-Output Multipliers
Michael Retzlaff and Lloyd Levy 94
(see the companion PowerPoint presentation)

The Effect of Oil Revenue on Consumption Expenditure in Iran
Ali Enami 126

Economic Impact of Federal Spending on Agriculture and Rural Economic Development Programs in Mississippi, 2010
Albert E. Myles 140

Measuring the Economic Impact of ASDI Benefits
Albert E. Myles 146

A Dynamic Demand Driven, Supply Constrained Input Output Approach to Modeling Economic Impacts of Water Disruption Events
Sara Alva-Lizarraga and Thomas G. Johnson 159

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An Exploration into Recent Input-Output Multiplier Innovations

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Abstract. One of the major purposes for using input-output models is to apply their multipliers. In addition to their ability to estimate secondary economic changes due to a large—seemingly infinite—variety of development projects, actions and proposals, input-output multipliers provide measurements of the intensities of the interindustry linkages within a region. These linkages tell us something very important about the internal structure of a region's economy. On might readily expect that the introduction of a new firm or sector in an area or the growth of existing firms would strengthen the local interindustry linkages because they potentially mean that there may be new sources of demand for other industries in the region or that there may be increases in supplies of previously imported materials and services—or, better yet, both occur.

Recently, a new procedure has been developed and implemented for constructing and compiling non-survey regional input-output models using a set of explicitly estimated interregional trade flows to estimate commodity-specific regional propensities to import. This paper compares the input-output multipliers derived from this new "trade flow" procedure with those derived using an older, econometrically-estimated procedure to derive regional propensities to import. Specifically, the changes in the output multipliers due to the introduction of new industries are compared. We suspect that these differences are due to differences internal modeling assumptions concerning local resource supply limitations that are imposed by the two multiplier methods. We suspect that the method used to "rebalance" the input-output accounts is causing the multipliers to decline as are new sector grows.

Introduction

Input-output multipliers provide measurements of the intensities of the interindustry linkages within a region. These linkages tell us something very important about the internal structure of a region's economy. On might readily expect that the introduction of a new firm or sector in an area or the growth of existing firms would strengthen the local interindustry linkages because they potentially mean that there may be new sources of demand for other industries in the region or that there may be increases in supplies of previously imported materials and services—or, better yet, both occur.

Recently, a new procedure has been developed and implemented for constructing and compiling non-survey regional input-output models using a set of explicitly estimated interregional trade flows to estimate commodity-specific regional propensities to import. This paper compares the input-output multipliers derived from this new "trade flow" procedure with those derived using an older, econometrically-estimated procedure to derive regional propensities to import. Specifically, the changes in the output multipliers due to the introduction of new industries are compared. To date, comparisons of the input-output multipliers derived from the two methods indicate that the "trade flow" multipliers fall when a new sector is introduced within a region and decline when the new sector grows. On the other hand, it appears that the "econo-metrically-based" input-output multipliers tend to increase when a new sector appears and increase as the new sector grows but then falls after a certain point. We suspect that these differences are due to differences internal modeling assumptions concerning local resource supply limitations that are imposed by the two multiplier methods. We suspect that the method used to balance the input-output accounts is causing the multipliers to decline as are new sector grows.

The agenda of the paper is as follows. First, we briefly discuss the relationship between new sectors in a local economy and the multiplier effects of existing industries. We expect that the introduction of a new sector will either not affect the intensity of the interindustry relationships (if the new sector neither uses locally available goods and services nor sells to local businesses) or it will increase the local multiplier effects. Second, we look at a recent example of a missing sector in a local economy, its introduction into the input-output accounts for that economy and the effects on the output multipliers of the region's existing sectors. Third, we look at more examples of introducing new sectors for a variety of industrial classes within five other local economies. Fourth, as a result of finding an inverse relationship between new industry introduction and the size of the multiplier effects, we see if negative value added elements in the input-output accounts affect our results. Finally, we conclude our discussion and make several recommendations.

Adding New Sectors to a an Input-Output Model and the Output Multipliers

There are several reasons why one would want to evaluate the effects of a "new" firm or industry. New firms are frequently heralded as "godsend" in most areas of the country. There are two ways to evaluate the economic effects of new firms with an input-output (IO) model. One can treat the new firm's intermediate goods spending and the purchases of its employees' as new sources of final demand for the existing sectors. On the other hand, if the new firm is part of an existing sector and produces the same product as the existing firms in that sector, then it is possible that the sales of the new firm's products may substitute for the sales of the existing firms. In either case, this assumes that the current patterns of transactions by the existing industries do not change as the new firm enters the local economy (Miller and Blair, 2009).

Consider a new firm that is part of a sector not presently represented in the region. In addition to being a new source of demand for other local firms' products, suppose that the new firm produces a product that is currently being imported by other firms in the local area. The new firm may offer its product at a cheaper price.[1] Existing firms can now switch from a more expensive imported source to a cheaper, locally available source. If the existing commodities propensities to consume locally are not changed by the introduction of the new firm (i.e., industry), then it is clear that each industry's overall regional propensity to consume locally will either remain constant or rise with the introduction of the new firm.[2]

[1] Locally available goods and services can be expected to be less expensive than the same goods and services that are imported simply because of lower transportation costs.

[2] Raising the overall propensities to consume locally (all things being equal), should increase the size of the output multipliers.

Table of Contents

An Example of a Missing Sector and Its Effect on Industry Output Multipliers

The usefulness of an input-output modeling system like IMPLAN relies heavily on the source of data that identifies which industrial sectors are located in a specific area.[3] However, it is not uncommon to find one or more "missing" sectors in any given area. For, example, in Boone County, Missouri there are a number of sectors found in the County Business Patterns file for 2007 that are not found in the 2007 IMPLAN database (Table 1).

[3] IMPLAN can compile input-output accounts for any area of the United States that is composed of one or more counties.

Table 1

What is and What is Not Located in Boone County, Missouri: 2007 IMPLAN and County Business Patterns

IMPLAN Industry Data File				Sectors Not Found in IMPLAN CBP Data: Boone County, Missouri								
Ind	*IMPLAN Description*	Ind Out	Emp	naics	empflag	emp_nf	emp	qp1_nf	qp1	ap_nf	ap	est
33	Water, sewage and other systems	$0.000	0	221310	B	D	0	D	0	D	0	2
60	Poultry processing	$0.000	0	311615	F	D	0	D	0	D	0	1
65	Snack food manufacturing	$0.000	0	311919	C	D	0	D	0	D	0	1
68	Seasoning and dressing manufacturing	$0.000	0	311941	A	D	0	D	0	D	0	1
87	Cut and sew apparel contractors	$0.000	0	315212	A	D	0	D	0	D	0	1
91	Apparel accessories and other apparel manufacturing	$0.000	0	315999	A	D	0	D	0	D	0	1
99	Wood windows and doors and millwork	$0.000	0	321912	A	D	0	D	0	D	0	1
119	All other petroleum and coal products manufacturing	$0.000	0	324199	B	D	0	D	0	D	0	1
133	Pharmaceutical preparation manufacturing	$0.000	0	325412	A	D	0	D	0	D	0	1
147	Urethane and other foam product (except polystyrene)	$0.000	0	326150	B	D	0	D	0	D	0	1
148	Plastics bottle manufacturing	$0.000	0	326160	A	D	0	D	0	D	0	1
188	Power boiler and heat exchanger manufacturing	$0.000	0	332410	A	D	0	D	0	D	0	1
215	Heating equipment (except warm air furnaces) manufac	$0.000	0	333414	E	D	0	D	0	D	0	1
225	Other engine equipment manufacturing	$0.000	0	333618	A	D	0	D	0	D	0	1
228	Material handling equipment manufacturing	$0.000	0	333922	A	D	0	D	0	D	0	1
242	Bare printed circuit board manufacturing	$0.000	0	334412	F	D	0	D	0	D	0	1
243	Semiconductor and related device manufacturing	$0.000	0	334413	B	D	0	D	0	D	0	1
294	All other transportation equipment manufacturing	$0.000	0	336999	A	D	0	D	0	D	0	1
310	Jewelry and silverware manufacturing	$0.000	0	339911	A	D	0	D	0	D	0	1
385	Facilities support services	$0.000	0	561210	B	D	0	D	0	D	0	1
				CBP empflag codes			A	0-19		E	250-499	
							B	20-99		F	500-999	
							C	100-249				

The fact that the IMPLAN database "misses" several sectors may not be too devastating if the missing sectors are "small". However, missing sectors with 100 or more employees (highlighted in yellow) could be questionable.

We recently completed an economic impact study of a small manufacturing plant located in Cross County, Arkansas (Robinson, 2011). Cross County is geographically situated approximately 50 miles west of Memphis, TN. The company uses a total production system for plastic injection molding, insert molding, gas assisted injection molding, painting, hydrographic decorating and assembly. Its major products consist of interior and exterior trims and functional complex modular assemblies for the automotive industry (NAICS 3633 or IMPLAN 283). These products include wheel covers, spoilers, body panels, body trim and taillight lenses, AT Shifter assemblies, door handle assemblies and exterior mirror assemblies. Currently the facility employs 30 people and pays those people an average hourly wage of $12.87. For purposes of this analysis, total annual wages and salaries for the 30 employees are $803,088 assuming that each employed person works full-time (i.e., 2,080 hours per year).

We compiled an input-output model for the Cross County, AR economy using its 2008 IMPLAN database and Version 3.0 IMPLAN software. The IO accounts were compiled by the "trade flow" method. However, we did not find sector 283 among the sectors in Cross County. The firm has been in operation at the site for a number of years, so it appears that it is missing from the database. Being industrious analysts, we decided to create a new sector employing 30 workers using the IMPLAN software and the recommended procedures (MIG, 2010). We reconstructed a new set of adjusted IO accounts. Examining the resulting output multipliers before and after the introduction of the new industry indicated that the output multipliers of the other existing industries fell as a result of the change in the industrial structure (compare columns of zero and 30 employees in Table 2).[4] For example, the multiplier for sector 358 fell from 1.5993 to 1.5984 and multiplier for sector 372 fell from 1.4604 to 1.4595.

[4] Table 2 presents the output multipliers for the target new sector for various employment levels and the resulting multipliers for a selection of ten other sectors.

Table 2

Cross County, AR: IMPLAN Trade Flow Type SAM Output Multpliers									
		Employment Size of Target Sector (283)							
Code	Description	0	1	5	10	30	50	100	500
283	Motor vehicle parts manufacturing	0.0000	1.2115	1.2113	1.2110	1.2101	1.2091	1.2068	1.1868
358	Insurance agencies, brokerages, and rela	1.5993	1.5993	1.5992	1.5990	1.5984	1.5978	1.5962	1.5810
425	Civic, social, professional, and similar org	1.5440	1.5440	1.5438	1.5437	1.5430	1.5424	1.5408	1.5145
424	Grantmaking, giving, and social advocacy	1.5367	1.5367	1.5366	1.5364	1.5358	1.5352	1.5336	1.5052
19	Support activities for agriculture and fore	1.4789	1.4789	1.4788	1.4788	1.4784	1.4781	1.4773	1.4489
372	Computer systems design services	1.4604	1.4603	1.4602	1.4601	1.4595	1.4589	1.4575	1.4342
401	Community food, housing, and other rel	1.4323	1.4323	1.4322	1.4321	1.4315	1.4310	1.4297	1.4060
355	Nondepository credit intermediation and	1.4287	1.4287	1.4286	1.4284	1.4279	1.4273	1.4260	1.4084
427	US Postal Service	1.4223	1.4223	1.4222	1.4221	1.4217	1.4213	1.4202	1.3967
348	Radio and television broadcasting	1.4204	1.4204	1.4204	1.4203	1.4200	1.4197	1.4190	1.4003
376	Scientific research and development serv	1.4115	1.4115	1.4113	1.4111	1.4103	1.4095	1.4075	1.3850

The results in Table 2 seem to reject our basic null hypothesis that introducing a new sector into an economy should either not change or raise the output multipliers of its existing industries. Although then size of the differences in the multipliers are small, the trend in the output multipliers created by increasing the size of the new sector is decidedly downward. But why?

We then tried the same experiment using the econometric method of generating IO accounts (Table 3). As shown, introducing the new sector appears to raise the existing industries' output multipliers as we expected—at least up to a point, 500 new workers.

Table 3

Cross County, AR: IMPLAN Econometric Type SAM Output Multpliers									
		Employment Size of Target Sector (283)							
Code	Description	0	1	5	10	30	50	100	500
283	Motor vehicle parts manufacturing	0.0000	1.2614	1.2968	1.3080	1.3259	1.3335	1.3422	1.3362
358	Insurance agencies, brokerages, and re	1.3938	1.3940	1.3947	1.3949	1.3952	1.3953	1.3953	1.3869
425	Civic, social, professional, and similar	1.5372	1.5376	1.5389	1.5394	1.5403	1.5409	1.5418	1.5211
424	Grantmaking, giving, and social advoc	1.5734	1.5741	1.5763	1.5770	1.5784	1.5792	1.5805	1.5571
19	Support activities for agriculture and f	1.5246	1.5251	1.5266	1.5272	1.5286	1.5296	1.5317	1.5057
372	Computer systems design services	1.4951	1.4954	1.4964	1.4967	1.4975	1.4980	1.4989	1.4788
401	Community food, housing, and other	1.4598	1.4608	1.4642	1.4653	1.4673	1.4683	1.4698	1.4504
355	Nondepository credit intermediation a	1.3592	1.3594	1.3600	1.3601	1.3604	1.3604	1.3604	1.3462
427	US Postal Service	1.4603	1.4639	1.4763	1.4803	1.4870	1.4900	1.4941	1.4784
348	Radio and television broadcasting	1.4574	1.4576	1.4584	1.4588	1.4595	1.4601	1.4612	1.4447
376	Scientific research and development s	1.4144	1.4150	1.4172	1.4178	1.4189	1.4194	1.4199	1.4037

Still More Examples

It is curious that these model compilation techniques would generate such different effects on the resulting output multipliers when a new sector is introduced into an economy. Next we made the same model comparisons for other new sectors in other parts of the State of Arkansas (see Tables 4 through 8).

County	**New Sector**
Craighead	Natural gas distribution (IMPLAN 32)
Drew	Fruit farming (IMPLAN 4)
Lee	Funds, trusts and other financial (IMPLAN 359)
Pulaski	Ice cream and frozen dessert manufacturing (IMPLAN 58)
Washington	Facilities support services (IMPLAN 385)

For all six (6) cases considered thus far, the trade flow procedure is generating output multipliers that decline when new sectors are added to economies and the decline is greater the larger the new sector. Even the output multiplier for the new sector declines as the employment level increases.

Table of Contents

Table 4

Craighead County, AR (target sector 32)			Employment Size of Target Sector (32)							
	Code	Description	0	1	5	10	30	50	100	500
Trade Flow Method Type SAM Output Multipliers	32	Natural gas distribution	0.0000	1.1456	1.1448	1.1439	1.1408	1.1385	1.1344	1.1233
	357	Insurance carriers	1.9352	1.9352	1.9350	1.9349	1.9343	1.9337	1.9322	1.9213
	358	Insurance agencies, brokerages, an	1.8426	1.8425	1.8424	1.8422	1.8415	1.8408	1.8391	1.8265
	346	Motion picture and video industrie	1.8099	1.8098	1.8097	1.8096	1.8090	1.8085	1.8074	1.7984
	404	Promoters of performing arts and	1.8083	1.8082	1.8081	1.8079	1.8074	1.8069	1.8057	1.7965
	424	Grant making, giving, and social ad	1.8037	1.8036	1.8034	1.8031	1.8022	1.8014	1.7992	1.7830
	425	Civic, social, professional, and sim	1.7914	1.7913	1.7911	1.7908	1.7898	1.7888	1.7865	1.7691
	372	Computer systems design services	1.7541	1.7540	1.7538	1.7535	1.7525	1.7516	1.7492	1.7314
	371	Custom computer programming se	1.7191	1.7190	1.7189	1.7186	1.7178	1.7171	1.7152	1.7012
	401	Community food, housing, and oth	1.7177	1.7177	1.7174	1.7172	1.7162	1.7153	1.7130	1.6958
	59	Animal (except poultry) slaughteri	1.7015	1.7014	1.7013	1.7011	1.7007	1.7004	1.6996	1.6937
	Code	Description	0	1	5	10	30	50	100	500
Econometric Method Type SAM Output Multipliers	32	Natural gas distribution	0.0000	1.1938	1.1915	1.1888	1.1802	1.1732	1.1606	1.1309
	357	Insurance carriers	1.5014	1.5014	1.5015	1.5016	1.5021	1.5021	1.5013	1.4959
	358	Insurance agencies, brokerages, an	1.5770	1.5770	1.5773	1.5775	1.5787	1.5787	1.5775	1.5692
	346	Motion picture and video industrie	1.7259	1.7260	1.7262	1.7266	1.7278	1.7280	1.7271	1.7219
	404	Promoters of performing arts and	1.6173	1.6174	1.6177	1.6180	1.6194	1.6196	1.6188	1.6135
	424	Grant making, giving, and social ad	1.7613	1.7614	1.7616	1.7620	1.7634	1.7633	1.7614	1.7484
	425	Civic, social, professional, and sim	1.7104	1.7106	1.7113	1.7122	1.7156	1.7163	1.7146	1.7032
	372	Computer systems design services	1.7012	1.7013	1.7015	1.7018	1.7030	1.7029	1.7008	1.6865
	371	Custom computer programming se	1.6385	1.6386	1.6387	1.6390	1.6399	1.6398	1.6381	1.6269
	401	Community food, housing, and oth	1.6875	1.6876	1.6880	1.6885	1.6904	1.6905	1.6884	1.6736
	59	Animal (except poultry) slaughteri	1.4064	1.4066	1.4077	1.4090	1.4143	1.4159	1.4150	1.4100

Table 5

Drew County, AR (target sector 4)			Employment Size of Target Sector (4)							
	Code	Description	0	1	5	10	30	50	100	500
Trade Flow Method Type SAM Output Multipliers	4	Fruit farming	0.0000	1.2334	1.2332	1.2330	1.2319	1.2309	1.2286	1.2140
	95	Sawmills and wood preservation	1.8195	1.8195	1.8194	1.8192	1.8187	1.8182	1.8170	1.8085
	16	Commercial logging	1.6275	1.6275	1.6274	1.6273	1.6267	1.6262	1.6250	1.6172
	358	Insurance agencies, brokerages, an	1.6199	1.6199	1.6198	1.6197	1.6191	1.6186	1.6173	1.6073
	357	Insurance carriers	1.6040	1.6040	1.6039	1.6038	1.6034	1.6029	1.6018	1.5934
	425	Civic, social, professional, and sim	1.5012	1.5011	1.5009	1.5006	1.4996	1.4985	1.4958	1.4759
	19	Support activities for agriculture a	1.4666	1.4665	1.4663	1.4660	1.4650	1.4639	1.4614	1.4418
	355	Nondepository credit intermediat	1.4423	1.4422	1.4421	1.4419	1.4411	1.4404	1.4386	1.4248
	424	Grant making, giving, and social ad	1.4404	1.4403	1.4402	1.4401	1.4394	1.4388	1.4373	1.4259
	99	Wood windows and doors and mi	1.4374	1.4373	1.4373	1.4372	1.4367	1.4363	1.4352	1.4276
	11	Cattle ranching and farming	1.4362	1.4361	1.4358	1.4354	1.4340	1.4326	1.4291	1.4035
	Code	Description	0	1	5	10	30	50	100	500
Econometric Method Type SAM Output Multipliers	4	Fruit farming	0.0000	1.4322	1.4340	1.4350	1.4357	1.4355	1.4304	1.3633
	95	Sawmills and wood preservation	1.9073	1.9073	1.9074	1.9074	1.9071	1.9068	1.9056	1.8939
	16	Commercial logging	1.5813	1.5814	1.5814	1.5814	1.5813	1.5810	1.5795	1.5618
	358	Insurance agencies, brokerages, an	1.4244	1.4244	1.4244	1.4244	1.4242	1.4239	1.4231	1.4167
	357	Insurance carriers	1.3622	1.3622	1.3623	1.3623	1.3621	1.3619	1.3613	1.3565
	425	Civic, social, professional, and sim	1.4828	1.4829	1.4830	1.4829	1.4825	1.4820	1.4806	1.4699
	19	Support activities for agriculture a	1.5016	1.5016	1.5018	1.5018	1.5012	1.5003	1.4981	1.4803
	355	Nondepository credit intermediat	1.3748	1.3749	1.3749	1.3749	1.3746	1.3743	1.3734	1.3665
	424	Grant making, giving, and social ad	1.4655	1.4655	1.4656	1.4656	1.4652	1.4648	1.4636	1.4543
	99	Wood windows and doors and mi	1.6649	1.6649	1.6650	1.6650	1.6647	1.6644	1.6634	1.6555
	11	Cattle ranching and farming	1.4362	1.4362	1.4362	1.4361	1.4357	1.4353	1.4337	1.4166

Table of Contents

Table 6

Lee County, AR (target sector 359)			Employment Size of Target Sector (359)							
	Code	Description	0	1	5	10	30	50	100	500
Trade Flow Method Type SAM Output Multipliers	359	Funds, trusts, and other financial v	0.0000	1.1497	1.1358	1.1232	1.0961	1.0836	1.0695	1.0446
	19	Support activities for agriculture a	1.1775	1.1774	1.1771	1.1768	1.1761	1.1756	1.1748	1.1510
	401	Community food, housing, and oth	1.1542	1.1540	1.1531	1.1523	1.1504	1.1494	1.1478	1.1219
	425	Civic, social, professional, and simi	1.1518	1.1513	1.1497	1.1481	1.1445	1.1424	1.1392	1.1173
	6	Greenhouse, nursery, and floricult	1.1515	1.1515	1.1513	1.1510	1.1505	1.1502	1.1495	1.1346
	424	Grant making, giving, and social ad	1.1495	1.1488	1.1464	1.1442	1.1387	1.1356	1.1309	1.1063
	409	Amusement parks, arcades, and ga	1.1494	1.1493	1.1489	1.1484	1.1468	1.1455	1.1425	1.1247
	374	Management, scientific, and techn	1.1423	1.1422	1.1417	1.1412	1.1396	1.1384	1.1360	1.1188
	427	US Postal Service	1.1421	1.1420	1.1417	1.1415	1.1407	1.1403	1.1395	1.1150
	398	Nursing and residential care facilit	1.1398	1.1398	1.1395	1.1392	1.1384	1.1379	1.1368	1.1168
	367	Legal services	1.1365	1.1364	1.1360	1.1357	1.1346	1.1339	1.1324	1.1179
	Code	Description	0	1	5	10	30	50	100	500
Econometric Method Type SAM Output Multipliers	359	Funds, trusts, and other financial v	0.0000	1.3162	1.2862	1.2577	1.1977	1.1702	1.1399	1.0895
	19	Support activities for agriculture a	1.3623	1.3644	1.3681	1.3672	1.3652	1.3641	1.3624	1.3131
	401	Community food, housing, and oth	1.3164	1.3171	1.3177	1.3158	1.3116	1.3094	1.3064	1.2547
	425	Civic, social, professional, and simi	1.3044	1.3092	1.3168	1.3130	1.3042	1.2995	1.2927	1.2489
	6	Greenhouse, nursery, and floricult	1.3032	1.3043	1.3062	1.3057	1.3043	1.3036	1.3023	1.2707
	424	Grant making, giving, and social ad	1.3122	1.3113	1.3074	1.3023	1.2903	1.2837	1.2738	1.2247
	409	Amusement parks, arcades, and ga	1.3304	1.3306	1.3305	1.3295	1.3264	1.3240	1.3188	1.2863
	374	Management, scientific, and techn	1.2856	1.2865	1.2877	1.2866	1.2835	1.2813	1.2771	1.2461
	427	US Postal Service	1.3333	1.3343	1.3360	1.3352	1.3335	1.3324	1.3308	1.2803
	398	Nursing and residential care facilit	1.2836	1.2849	1.2870	1.2863	1.2844	1.2832	1.2813	1.2408
	367	Legal services	1.2631	1.2641	1.2656	1.2647	1.2625	1.2610	1.2583	1.2304

Table 7

Pulaski County, AR (target sector 58)			Employment Size of Target Sector (58)							
	Code	Description	0	1	5	10	30	50	100	500
Trade Flow Method Type SAM Output Multipliers	58	Ice cream and frozen dessert manu	0.0000	1.6721	1.6715	1.6706	1.6669	1.6633	1.6547	1.6057
	359	Funds, trusts, and other financial v	2.6369	2.6369	2.6368	2.6368	2.6365	2.6363	2.6357	2.6314
	424	Grant making, giving, and social ad	2.2371	2.2371	2.2371	2.2370	2.2367	2.2364	2.2356	2.2300
	425	Civic, social, professional, and simi	2.0950	2.0950	2.0949	2.0948	2.0946	2.0943	2.0936	2.0887
	357	Insurance carriers	2.0651	2.0651	2.0651	2.0650	2.0649	2.0647	2.0643	2.0614
	356	Securities, commodity contracts, in	2.0362	2.0361	2.0361	2.0361	2.0358	2.0356	2.0350	2.0309
	409	Amusement parks, arcades, and ga	2.0119	2.0119	2.0118	2.0117	2.0114	2.0111	2.0103	2.0041
	348	Radio and television broadcasting	1.9897	1.9897	1.9897	1.9896	1.9894	1.9892	1.9888	1.9853
	403	Spectator sports companies	1.9699	1.9698	1.9698	1.9697	1.9694	1.9692	1.9685	1.9632
	404	Promoters of performing arts and	1.9357	1.9357	1.9357	1.9356	1.9354	1.9352	1.9347	1.9308
	365	Commercial and industrial machin	1.9337	1.9336	1.9336	1.9335	1.9331	1.9327	1.9318	1.9245
	Code	Description	0	1	5	10	30	50	100	500
Econometric Method Type SAM Output Multipliers	58	Ice cream and frozen dessert manu	0.0000	1.4660	1.4740	1.4841	1.5014	1.5058	1.5108	1.5166
	359	Funds, trusts, and other financial v	1.9041	1.9041	1.9041	1.9041	1.9042	1.9042	1.9042	1.9038
	424	Grant making, giving, and social ad	1.8545	1.8545	1.8546	1.8547	1.8549	1.8549	1.8548	1.8539
	425	Civic, social, professional, and simi	1.7598	1.7598	1.7599	1.7600	1.7602	1.7602	1.7602	1.7593
	357	Insurance carriers	1.4773	1.4773	1.4774	1.4774	1.4775	1.4775	1.4774	1.4771
	356	Securities, commodity contracts, in	1.6404	1.6404	1.6404	1.6405	1.6406	1.6406	1.6405	1.6400
	409	Amusement parks, arcades, and ga	1.6091	1.6092	1.6093	1.6096	1.6100	1.6101	1.6103	1.6108
	348	Radio and television broadcasting	1.7545	1.7545	1.7546	1.7547	1.7549	1.7549	1.7549	1.7547
	403	Spectator sports companies	1.6246	1.6246	1.6247	1.6248	1.6250	1.6253	1.6257	1.6292
	404	Promoters of performing arts and	1.5862	1.5862	1.5863	1.5863	1.5864	1.5864	1.5864	1.5859
	365	Commercial and industrial machin	1.5821	1.5821	1.5821	1.5822	1.5822	1.5822	1.5822	1.5817

Table 8

Washington County, AR (target sector 385)			Employment Size of Target Sector (385)							
	Code	Description	0	1	5	10	30	50	100	500
Trade Flow Method Type SAM Output Multipliers	385	Facilities support services	0.0000	1.3935	1.3935	1.3934	1.3933	1.3932	1.3928	1.3900
	424	Grant making, giving, and social ad	1.6960	1.6960	1.6960	1.6960	1.6958	1.6957	1.6953	1.6923
	341	Newspaper publishers	1.6637	1.6637	1.6636	1.6636	1.6636	1.6635	1.6633	1.6620
	350	Internet publishing and broadcast	1.6496	1.6496	1.6496	1.6495	1.6494	1.6493	1.6491	1.6471
	425	Civic, social, professional, and simi	1.5867	1.5867	1.5867	1.5866	1.5865	1.5865	1.5862	1.5843
	357	Insurance carriers	1.5845	1.5845	1.5845	1.5845	1.5844	1.5844	1.5842	1.5830
	358	Insurance agencies, brokerages, an	1.5494	1.5494	1.5494	1.5494	1.5493	1.5492	1.5489	1.5469
	392	Private junior colleges, colleges, un	1.5294	1.5294	1.5294	1.5294	1.5293	1.5292	1.5290	1.5276
	372	Computer systems design services	1.4961	1.4961	1.4961	1.4960	1.4959	1.4958	1.4956	1.4937
	393	Other private educational services	1.4953	1.4953	1.4953	1.4953	1.4952	1.4951	1.4949	1.4931
	401	Community food, housing, and oth	1.4942	1.4942	1.4942	1.4941	1.4941	1.4940	1.4937	1.4918
	Code	Description	0	1	5	10	30	50	100	500
Econometric Method Type SAM Output Multipliers	385	Facilities support services	0.0000	1.5694	1.5695	1.5696	1.5701	1.5699	1.5696	1.5665
	424	Grant making, giving, and social ad	1.9222	1.9222	1.9222	1.9223	1.9224	1.9222	1.9218	1.9181
	341	Newspaper publishers	1.4036	1.4036	1.4036	1.4037	1.4038	1.4037	1.4036	1.4024
	350	Internet publishing and broadcast	1.3126	1.3126	1.3127	1.3127	1.3128	1.3128	1.3127	1.3121
	425	Civic, social, professional, and simi	1.7641	1.7641	1.7642	1.7642	1.7643	1.7642	1.7639	1.7618
	357	Insurance carriers	1.4686	1.4686	1.4687	1.4688	1.4691	1.4691	1.4689	1.4679
	358	Insurance agencies, brokerages, an	1.5633	1.5633	1.5635	1.5637	1.5644	1.5643	1.5641	1.5622
	392	Private junior colleges, colleges, un	1.7085	1.7085	1.7085	1.7085	1.7086	1.7085	1.7083	1.7070
	372	Computer systems design services	1.6944	1.6945	1.6945	1.6946	1.6948	1.6947	1.6944	1.6921
	393	Other private educational services	1.5477	1.5478	1.5478	1.5479	1.5483	1.5482	1.5480	1.5465
	401	Community food, housing, and oth	1.7158	1.7158	1.7159	1.7160	1.7164	1.7163	1.7160	1.7138

However, the patterns of the changes in the multipliers as the new industry's employment level increases are more interesting for the econometric IO model reconstruction technique than for the trade flow procedure. Looking over Tables 4 through 8 it appears that the existing industries' output multipliers start rising as the new firm increases in size but then begins to fall after a particular size.

Is the Inverse Relationship Between New Sector Introduction and Multiplier Size Due to Negative Value Added Components?

Each of the six regions had several column sums of the industry-by-industry regional input coefficient matrix that were greater than one. This is due to the existence of negative value added components for a number of industries. For example, Table 9 shows the employment, output and value added levels for each industry that had negative value added components in Pulaski County. As result, we adjusted the basic industry data. We recomputed industry output for those sectors that had negative values added elements by assuming the intermediate purchases calculated by IMPLAN were correct (the difference between the initial output estimate and the sum of the value added components) than then by "zeroing out" the negative value added elements. The recomputed output estimate is the sum of the intermediate input purchases and the non-negative value added elements.

Table 9

2008 Industry Employment, Output and Value Added (with negative components): Pulaski County, Arkansas							
Code	Industry	Employ-ment	Output	Employee Comp	Proprietor Income	Property-Type Income	Indirect Business Tax
4	Fruit farming	1	$119	$18	$34	-$25	$4
19	Support activities for agriculture and f	94	$3,482	$2,484	$1,098	-$565	$54
72	Wineries	18	$7,803	$1,469	$300	-$36	$668
107	Paperboard container manufacturing	173	$55,261	$9,329	$404	-$243	$390
185	Handtool manufacturing	8	$312	$222	$18	-$168	$1
295	Wood kitchen cabinet and countertop	541	$69,547	$16,982	$308	-$59	$258
316	Musical instrument manufacturing	3	$362	$139	$12	$0	$1
333	Transport by rail	1,594	$602,134	$139,854	-$326	$121,708	$7,354
337	Transport by pipeline	169	$144,645	$18,103	$3,010	-$792	$6,358
348	Radio and television broadcasting	1,243	$352,095	$48,185	$116,081	-$4,982	$10,820
356	Securities, commodity contracts, inve	4,262	$787,658	$254,128	$14,906	-$10,716	$6,233
363	General and consumer goods rental e	739	$55,050	$26,152	$300	-$980	$2,598
369	Architectural, engineering, and relate	3,118	$314,151	$145,499	$41,220	-$52	$1,469
371	Custom computer programming serv	1,963	$158,993	$92,261	$16,057	-$1,535	$3,829
372	Computer systems design services	1,926	$210,127	$83,282	$38,104	-$15,668	$2,849
376	Scientific research and development	167	$16,881	$4,603	$2,599	-$722	$48
381	Management of companies and enter	4,429	$748,865	$283,105	-$21	$62,858	$5,789
382	Employment services	10,638	$263,373	$173,306	$18,780	-$671	$1,023
406	Museums, historical sites, zoos, and p	59	$13,781	$1,413	$9,907	-$1,140	$426
407	Fitness and recreational sports cente	673	$23,018	$12,108	$9	-$158	$979
420	Death care services	277	$22,570	$8,644	$1,764	-$839	$1,146
423	Religious organizations	18	$1,309	$743	$3	-$4	$0
424	Grantmaking, giving, and social advoc	2,713	$212,051	$97,700	$939	-$15,964	$1,814
425	Civic, social, professional, and simila	1,576	$107,126	$69,418	$499	-$8,449	$3,798
430	State and local government passenge	242	$23,364	$14,490	$0	-$12,645	$0
Notes: Employment in full- and part-time jobs and monetary values in thousands of 2008 dollars.							
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The adjusted output and valued components were incorporated into the IMPLAN database and the IO model was reconstructed. The same set of multiplier experiments as above was undertaken for aircraft engines and engine parts manufacturing (Sector 285) in Pulaski County and the results are shown in Table 10. Again, the same inverse relationship occurs between the size of a new industry and the magnitudes of the output multipliers for the existing sectors.

Table of Contents

Table 10

			Neg VA	Negative Value Added Adjusted							
Pulaski County, AR (target sector 285)			Not Adj	Employment Size of Target Sector (385)							
	Code	Description	0	0	1	5	10	30	50	100	500
Trade Flow Method Type SAM Output Multipliers	285	Aircraft engine and engine parts m	0.0000	0.0000	1.4575	1.4575	1.4575	1.4573	1.4572	1.4568	1.4540
	359	Funds, trusts, and other financial v	2.7431	2.7287	2.7286	2.7286	2.7285	2.7283	2.7281	2.7275	2.7228
	357	Insurance carriers	2.2942	2.2918	2.2918	2.2918	2.2918	2.2916	2.2915	2.2912	2.2885
	356	Securities, commodity contracts, in	2.1911	2.1695	2.1695	2.1695	2.1694	2.1693	2.1691	2.1687	2.1651
	4	Fruit farming	2.0779	1.8862	1.8862	1.8861	1.8861	1.8860	1.8859	1.8857	1.8839
	424	Grantmaking, giving, and social ad	2.0597	1.9823	1.9823	1.9823	1.9822	1.9821	1.9819	1.9815	1.9784
	358	Insurance agencies, brokerages, an	2.0347	2.0331	2.0331	2.0330	2.0330	2.0329	2.0327	2.0323	2.0295
	365	Commercial and industrial machin	2.0301	2.0283	2.0283	2.0282	2.0282	2.0279	2.0277	2.0272	2.0228
	185	Handtool manufacturing	2.0299	1.6685	1.6685	1.6685	1.6685	1.6683	1.6682	1.6678	1.6651
	362	Automotive equipment rental and	2.0084	2.0063	2.0063	2.0063	2.0062	2.0060	2.0058	2.0053	2.0013
	364	Video tape and disc rental	2.0005	1.9991	1.9991	1.9991	1.9990	1.9988	1.9986	1.9980	1.9934
	Code	Description	0	0	1	5	10	30	50	100	500
Econometric Method Type SAM Output Multipliers	285	Aircraft engine and engine parts m	0.0000	0.0000	1.3138	1.3181	1.3234	1.3448	1.3661	1.4191	1.5966
	359	Funds, trusts, and other financial v	1.8983	1.8933	1.8933	1.8933	1.8933	1.8933	1.8932	1.8932	1.8927
	357	Insurance carriers	1.5737	1.5729	1.5729	1.5729	1.5729	1.5729	1.5729	1.5728	1.5723
	356	Securities, commodity contracts, in	1.7191	1.7074	1.7074	1.7074	1.7074	1.7073	1.7073	1.7072	1.7064
	4	Fruit farming	1.5560	1.4619	1.4619	1.4619	1.4619	1.4619	1.4619	1.4619	1.4615
	424	Grantmaking, giving, and social ad	1.7204	1.6686	1.6686	1.6686	1.6686	1.6686	1.6685	1.6684	1.6675
	358	Insurance agencies, brokerages, an	1.6140	1.6134	1.6134	1.6134	1.6134	1.6133	1.6133	1.6132	1.6123
	365	Commercial and industrial machin	1.6493	1.6485	1.6485	1.6485	1.6485	1.6485	1.6485	1.6484	1.6478
	185	Handtool manufacturing	1.7249	1.4710	1.4710	1.4710	1.4710	1.4709	1.4709	1.4708	1.4700
	362	Automotive equipment rental and	1.6300	1.6290	1.6290	1.6290	1.6290	1.6290	1.6290	1.6289	1.6283
	364	Video tape and disc rental	1.6407	1.6402	1.6402	1.6402	1.6402	1.6402	1.6402	1.6401	1.6396

Conclusions and Recommendations

Based on the analysis above using IMPLAN Version 3.0 software, we appear to have identified a distinctly inverse relationship between the sizes of new sectors that are added to a region economy and the magnitudes of the output multipliers of the existing industries. This is quite contrary to our original hypothesis that new industries should either not change existing sectors' output multipliers or they should raise them. In fact the inverse relationship appears to be quite pervasive and empirically dominant—especially for IMPLAN's trade flow IO model construction technique.

As an explanation for this contrary result, we postulate that there seems to be a local supply limitation being created within IMPLAN during the IO accounts balancing process. This would raise existing firms' propensities to import as more firms are added to the local economy. Or, that there is some other leakage that we have not yet identified.

We suggest that the issue lies in the IO accounts balancing process. IMPLAN uses a RAS procedure that is iterative and, in general, adjusts intermediate purchases while maintaining existing output, value added and final demand estimates. As an alternative, the U.S. Bureau of Economic Analysis (BEA) is implementing a new procedure to balance their National Annual Update IO Accounts developed by Baoline Chen (2006).[5] The advantage of the new procedures over the old (i.e., RAS) is that the new method simultaneously solves for IO accounts balancing using a GLS reconciliation method that optimally incorporates all available information concerning independently

[5] See Rassier et al. (2007) for details about the implementation of the new BEA National Annual Update IO Accounts balancing procedures.

estimated output, value added and final demand. In addition, a gross operating surplus (the sum of proprietor's income and other property-type income) is estimated along with a new set of intermediate purchases for each industry.[6]

Existing input-output and regional impact modeling methods (such as IMPLAN, REMI and RIMS) do not appear to handle IO structural change analysis very well. The latter two systems do not even have functions that permit changes in the IO structure. IMPLAN does allow users ways to alter the IO structure of an economy, such as deleting and adding sectors. However the evidence shown here may indicate modeling issues.

We recommend that more focus on be placed on the analysis of structural change. Several of IO modeling innovations exist in which to analyze incremental structural change issues. For example, non-linear and dynamic input-output models have been developed to evaluate the effects of changes in transportation and input costs, relative price changes and resource supply limitations. The key to these analyses is the ability to change input structures resulting from supply limitations and cost changes.[7]

In terms of structural economic shifts like the disappearance of local sectors is fairly well developed using hypothetical extraction techniques.[8] We feel that a "hypothetical insertion" method is needed for the case where new industries appear. The technique would be analogous to the hypothetical extraction methods. Such a system would allow for or have the ability to

- Expansion of local existing firms' capacities to accommodate the new sector or sectors,
- Alternative production function libraries,
- Exploration of possible sales distributions, and (of course)
- Input-output accounts balancing.

[6] The gross operating surplus acts as a "statistical" discrepancy in the IO accounts construction process.

[7] See Liew & Liew (1985), Liew (2005), West & Jackson (2004) and Alva-Lizarraga & Johnson (2012). CGE models almost invariably assume the IO structure is dominate by Leontief production processes. Analysts using CGE models claim that they, too, can analyze issues where the IO structure changes. However, examples of this are rare.

[8] See Dietzenbacher & Lahr (2008), Miller & Lahr (2001) and Ten Raa (2007).

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Measuring University Contributions to Regional Economies: A Discussion of Guidelines for Enhancing Credibility

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Introduction

Public universities are complicated and diverse institutions. They provide a very wide range of services, and the users and providers of those services interact with one another and with society in very unique manners. Accordingly, their ostensible values to the economy and to society are both tangible, in that they can be quantified using a variety of conventional measures, and they are intangible in that they infuse and enhance a states' cultural, historical, and recreational heritage and identities.

A university's presence in a region or a university system in a state may exert considerable influence on educational opportunities, cultural options, recreational choices, and the tone and tenor of regional economic vitality. Universities are large, they employ many people, they serve even more people, and they are directly and indirectly responsible for substantial fractions of regional incomes. A university influences the types of businesses in an area, housing values, the availability of area goods and services, and private and public infrastructure investments. In short, most universities have large and lasting economic and social footprints.

Many public universities have found it necessary to measure and promote their regional or statewide economic values in recent years, especially in light of tight state fiscal accounts, keen competition among service providers for scarce dollars, and a poorly performing national economy. A review of a sample of those efforts will lead one to conclude that some are basic, straightforward, and reasonable, while others strain credulity as they seek unconventional ways to describe university contributions to regional economic well-being. As credibility is an important objective of university economic studies, efforts to standardize measurements and measurement procedures appear to be needed in order to allow policy makers and citizens to compare universities with other types of public and private services as well as compare institutions with one another.

Recent Efforts to Reform University Impact Studies

Siegfried, et al, surveyed the state of the art of university impact studies in 2007.[1, 2] This well

[1] Siegfried, John J., Allen R. Sanderson, Peter McHenry. The Economic Impact of Colleges and Universities. Economics of Education Review. 26 (2007) 546-558.

[2] Evaluations of higher education impacts often refer to much earlier work done in 1992 by Leslie and Slaughter. See Leslie, L.L., and Slaughter, S.A. Higher Education and Regional Development, in F. Welch & E Hanushek (eds), The Economics of American Higher Education. Dordecht: Klewer Academic Publishers. 1992.

focused and to-the-point critical article was met with both consternation and concern among organizations concerned with promoting higher education and maintaining public support for higher education policies. Consternation because university impact studies had become important components of university marketing – indeed, university marketing in many cases had taken over the process of sponsoring and publishing university impact studies. Concern in that it was obvious the state of the art was, as the article revealed, woefully lacking.

Siegfried, et al, were blunt in their evaluation of university economic impact efforts. After reviewing dozens of modern examples, they concluded

- Evaluators and clients were prone to use inappropriately compiled data or misleading ratios and inferences when describing higher education economic importance.
- Little attention was paid to identifying and justifying the appropriate geographic territory, and in so doing, evaluators failed to distinguish between what would be considered the required education services to tend native demand, versus, literally, education sales in excess of regional demand (i.e., the net gains in regional productivity or the actual marginal economic impacts associated with increments of higher education service).
- Inappropriate or ill-applied multipliers were frequently employed that were either not reflective of the region's economic structure, or not reflective, when applied in a detailed fashion, of the institution's actual purchasing patterns in the area economy.
- Too much effort was made trying to quantify secondary, tangential economic impacts, to include knowledge spillovers and economic activity that would seem to logically flow from a university (consulting, business start-ups, etc., to include enhanced community quality of life measures).
- Broadly, the authors criticized the manufacturing of inappropriate ratios (leverage levels, return on investment language, etc.,) as well as confusing reporting that do not lend themselves to reporting clarity.

Their evaluation also listed sets of "shoulds" they thought appropriate to generating public confidence in university studies.

- All university economic impact research should begin with a clear counterfactual – essentially a careful evaluation of a region's economic structure with and without the institution so as to have the potential of isolating incremental regional economic gains.
- Studies should apply to the issue at hand, and the beneficial outcomes of a university or an increment to its production ought to be compared specifically to the project or policy that is being debated or proposed. Broad, grandiose declarations, in their view, should be minimized, though that is the norm of modern studies
- The study area must make sense vis-à-vis the conclusions that are to be drawn. A small regional educational institution cannot have a statewide economic impact.

- Care should be taken in identifying first round (or direct) spending that would normally have occurred versus that which is considered due to university export sales activity to students, attendance at athletic or cultural events, and in other university functions.
- Correct multipliers (or modeling systems) must be employed. Many studies they found deployed multipliers of dubious origins.
- No double counting. For example student spending must be counted where it happens. Student spending within the institution, for example, must not also be counted again under a student spending impact summary.
- Finally spillovers may be acknowledged and described, but they probably can't be well measured, most certainly with traditional impact analysis structures. This is more of a substantive summary of university importance as opposed to a quantitative outcome.

This work has influenced how higher education associations view university impact studies. The Association of Public and Land-grant Universities, APLU, as one example, has engaged in a series of ongoing discussions designed to determine best practices for university impact assessments. Those discussions involved economists from the Bureau of Economic Analysis who manage the agency's RIMS II activities, along with representatives of several universities interested in improving the quality of university studies and providing a basis for legitimate comparisons among universities. Those discussions have been led by the APLU's Commission on Innovation, Competitiveness, and Economic Prosperity (CICEP), and includes also the Association of American Universities (AAU) as a cooperating partner in the effort.[3] The expected outcomes of this collaboration involve the sponsorship of workshops featuring BEA representatives demonstrating best-procedures for measuring a wide range of university activities using a RIMS II estimation protocols. Those workshops will also include presentations on modifying and applying input-output analysis systems like IMPLAN to more accurately evaluate university-related activities.

Integral to this process have been discussions and the development of tentative guidelines to determine what properly fits within a multiplier-driven economic framework and what can legitimately be concluded from that process. The project intends to culminate with a BEA technical report on this topic, plus an update to the BEA's RIMS II users' handbook.[4]

This paper is not a primer on the nuts and bolts of input-output, benefit-cost, or any other type of conventional analysis of the near and long term worth of public education institutions. It is instead a guide for public university economic impact practitioners for planning, structuring, evaluating, and distributing higher education economic information for use in policy development, planning, and university rela-

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[3] Leadership in the CICEP activities on this topic has been provided by senior representatives of Iowa State University. I provide technical and interpretive assistance to those administrators in their efforts.

[4] Bureau of Economic Analysis, REGIONAL MULTIPLIERS: A User Handbook for the Regional Input-Output Modeling System (RIMS II), 3rd edition. U.S. Department of Commerce. 1997.

tions. As an active participant in the CICEP – APLU reform efforts, I have had the opportunity to evaluate the objectives of this reform process and share my substantive and procedural concerns relating to university economic impact analyses.

This paper is also not a comprehensive evaluation of the range of studies that have been produced, though dozens have been perused over the years by this writer. It represents my sense as to the more appropriate and more credible approaches universities should take when documenting the economic potency of a university system. Infused within, therefore, are normative considerations in that there are several "oughts" and "ought nots" described.

The paper is motivated by and organized considering one over-riding premise: when measuring public universities and their contributions to regional or statewide economies and society at-large, do it right or don't do it at all. Universities are houses of high standards, and those high standards should apply to all university products. Economic impact summaries must not be an exception to that rule.

And as Siegfried, et al, noted:

"If college impact studies were conducted at the level of accuracy most institutions require of faculty research, we would see fewer preposterous claims like a 2600 percent annual rate of return …. This would improve public trust in higher education officials."[5]

The following represents my summary of some procedural and substantive steps that might be adhered to in enhancing university economic impact studies, especially given the Siegfried, et al, review of the state of the art. The guidelines are organized as first those relating to measurement and analysis, and next, those relating to reporting the results or describing universities' values to society. It is written for economists interested in producing these types of studies, and it is written for university officials interested in understanding this topic or who might want to commission this type of evaluation.

Measuring University Economic Contributions and Economic Impacts

Using Modeling Systems or Tables of Multipliers

U.S. public universities are a complicated amalgam of institutions that depend on taxpayer support, fees and charges, donations, and grants to provide

- Higher education services
- Medical or veterinary care
- Research, development, and technology transfer services
- Recreational, entertainment, and cultural activities

The degrees to which any given institution produces these services may vary widely, but in the main, the primary justification for our universities is to deliver higher education to in-state residents, and secondarily, to out-of-state students. They are a component of state government spending, and when state governments reconcile their annual accounts using Generally Accepted Accounting Principles, all of the revenues and outlays of our public higher

[5] Siegfried, et al, (2007) p. 557.

education systems are properly documented as state general fund activities.

Like all categories of government services, public universities are distinct and easily measured subsets of state or regional economies. Their revenue sources and their spending decisions are a matter of public record, and it does not require much investigation to isolate any university's annual report of activities. When done, overall higher education outlays can be easily compared to other state government services, as can their sources of revenues. For a one year period or over time, this basic method of assessing public higher education spending can yield a wealth of useful information about public support, spending efficiencies, employment changes, and the range of services provided by our universities.

Over the years, however, there has been a growing emphasis on identifying the "economic impacts," or, perhaps more accurately, the economic "contributions" of our universities to regional or state economies. These kinds of measures take into account not only a university's actual direct spending for payroll, goods, and services, but also consider the indirect effects a university system has on in-state (or in-region) suppliers to the university, as well as all of the economic activity that emanates from university and supplying-sector employee spending as they convert their paychecks into household purchases.

Properly done, this estimation process identifies a multiplier effect attributable to university spending in terms of total regional (or statewide) business activity, incomes to workers, and jobs that is greater than the annual outlays of the university, its staffing, and payroll. It allows officials to claim a modicum of regional economic potency in excess of reported annual spending, along with regional economic importance extending beyond the normal boundaries of a university primary service and employment area. A university's multiplier effects for a region or a state are primarily determined through the use of two conventional mechanisms:

1. Researchers will construct a suitably detailed input-output (IO) model of the regional economy of scrutiny, or
2. Researchers will apply a set of higher education multipliers to total university outlays or, alternatively, it will apply a detailed schedule of multipliers to itemized university outlays that occur in the region.

A widely-used IO modeling system is distributed by Minnesota Implan Group, Inc (MIG). Their model structure allows skilled analysts to configure a study subject's industrial accounts, in this case a public university, in a manner that is generally consistent with IO measurement procedures. MIG has been supplying data for substate-level modeling for over 25 years, and is the most relied-upon source for IO data among academics and government agencies. Implan models have high industrial specificity, as well as high regional specificity. There are 440 industrial sectors in the national Implan model, and study regions can be a zip-code area, a county, a combination of contiguous counties, state, state combinations, or the nation.

A common source for industrial multipliers is the RIMS II system of the U.S. Bureau of Economic Development. RIMS II is not an IO model; instead, the service produces for-a-fee regionally-specific multipliers from IO models managed internally at BEA. Analysts then apply the multipliers to their scenario of interest. As the BEA is the U.S.'s chief agency for compiling national industrial information, the agency periodically produces benchmark input output accounts at the national level, which serve as the technical foundation for most IO systems used in the U.S.

Whether analysts use an input-output model or a table of multipliers, it is essential they utilize coefficients that are appropriate to the region of analysis. A researcher studying a statewide university system would use an IO model or table of multipliers specified for that particular state. It is inappropriate to use multipliers from another state or from the nation. There is wide variance in multipliers across states owing to their sizes and the overall mix of industries that might be found in, say, a South Dakota versus an Oregon. The use of state multipliers to estimate a much smaller sub-region, or the use of national multipliers to measure a state both have the effects of minimizing trade leakages and over-describing economic activity. It is also inappropriate to use some sort of single, trans-university multiplier for institutions in different states.

Last, there are continuous transformations in regional and state economies. It is preferred that analysts use modeling systems or multipliers that are as recent as possible. Implan modeling for 2011 relies on industrial estimates for 2009. The current RIMS II multipliers are based on 2007 industrial estimates.

Any study of university economic contributions to a regional or a statewide economy must employ proper and up-to-date modeling systems.

- Are the analysts using a current IO modeling system like Implan or its structural equivalent, or a current table of RIMS II multipliers, and

- Have the models or the multiplier tables been specified for the appropriate region of analysis?

The Estimation Process and Reliable Reporting

Using a table of industrial multipliers or analyzing a university using an input-output (IO) model requires education, topical aptitude, and experience. IO industrial accounting systems have inherent strengths and weaknesses, and practiced analysts are mindful of those attributes when utilizing either IO models or tables of multipliers. The core ability to operate a modeling software system or use a spreadsheet to apply RIMS II multipliers is not in and of itself sufficient to engender confidence in measurement results. In addition, most university graduate economic programs do not provide course work on input-output systems development beyond the introductory level, so even economists are to be scrutinized carefully.

There are, in short, a range of competencies and perspectives that should be evidenced when conducting IO or multiplier analysis. Among common the competencies might include:

- An ability to modify a study region's social accounts in an IO system so that, for example, the higher education sector contained the actual labor costs, jobs, and major expenditure categories of the entity being studied.
- An understanding of the probability that procured goods or services are purchased from within-region suppliers, and an understanding of how to estimate and adjust for the likelihood of a regional purchase.
- A demonstrated understanding, whether using an IO model or a table of multipliers method, of the special treatment one must afford trade and transportation margins.
- An understanding of the temporal limits to IO model or table of multiplier projections.
- A demonstrated understanding of the elements of output, in particular the value added components of the results.
- An ability to explain to the taxpaying public what the findings mean and how they were arrived at.

Importantly, analysts conducting IO or table of multiplier analyses should be able to discuss the underlying structures of all IO models and tables of multipliers, to include all of the elements and steps of a standard multiplier-producing process, known academically as the Leontief input-output modeling technique. Analysts lacking this type of background are certainly capable of operating modeling systems or applying tables of multipliers correctly, but they may be unable to answer questions about the foundations of IO analysis and its inherent limits and strengths.

The ability of the analyst is of primary importance in conducting university economic impact reports as the quality of the research will directly reflect on the higher institution at large:

- Do the analysts demonstrate a solid and thorough understanding of IO methods and procedures, and

- Can the analysts adequately explain and defend findings to the public, policy makers, or the media with the kind of confidence and authority that universities expect from all of their scholars?

Describing Total Economic Contributions and Estimated Economic Impacts

State universities are an intrinsic component of any state's economy. They have evolved over time to satisfy resident population needs, and while many states have one or two dominant institutions, they also have many smaller technical and four year colleges distributed on a regional basis or that have evolved as population changes have demanded. A state's university system typically can be seen as a regular component of state public service delivery that satisfies educational, health care, cultural, and recreational demands. Accordingly, state universities contribute to the state's economy in important, measurable, and expected ways.

The degree to which a university constitutes a regional or statewide economic impact, however, is some subset of its overall economic contribution. Regular university education, health care, cultural, or recreational services that have evolved to satisfy current in-state population demands are intrinsic and long-standing components of the economy. One does not realistically talk about a “with or without” situation as public higher education and all of the concomitant activities normally associated with university systems would unarguably exist somewhere in the state. But universities do engage in service exports in that they host out-of-state students or they otherwise attract visitors to their educational, health care, cultural, or recreational activities who otherwise might not have done so “but-for” the presence of the university. Universities also export research and technical transfer services, most especially in the cases where research is sponsored by federal sources, foundations, or directly by private industries.

Student spending in the broader economy outside of the college also constitutes an important contribution to regional economic accounts, but in-state student spending, again, would have occurred somewhere within the state and thus should initially be measured in terms of its localized contribution to regional economic activity. Like university operations in general, however, off-campus spending by out-of-state students and visitors in fact represents net additions to regional and statewide consumption. That subset of regional spending will also constitute an economic impact, and can be segregated to make that point.

A clear understanding of regional economic accounts, for example, to include the ability to differentiate between economic activity that is intrinsic to a state or regional economy versus that which would be considered net new regional or statewide productivity, is essential to producing credible studies of overall university economic contributions and economic impacts.

- Are the analysts able to clearly describe and distinguish economic activity that has occurred in the state or region “but-for” the presence of the university from the activity that would have occurred nonetheless by virtue of expected state service delivery, and

- Have the analysts carefully segregated their evaluation so that it is clear to readers which components of regional or statewide economic contribution and impact are attributable to university activities and which are attributable to the activities of students and visitors?

Identifying and Measuring Extra-University Economic Activity

Student and visitor spending levels along with their area spending preferences should be measured using reliable survey methods if possible. Reliable survey methods have sufficient survey sample sizes, are drawn properly from a pre-identified population, and can adequately describe the population’s attributes in enough detail as to engender statistical confidence in the results. This is especially true for the range of non-student consumers of university activities as they are a very heterogeneous group. Surveys of all attendees to workshops, summer camps, cultural events, athletic activities, medical facilities, and regular university educational programming would have to encompass an entire year, would have to be of sufficient sample size so as to adequately characterize major classes of visitors, and would adequately differentiate among visitors whom were in-state versus those that were out of state for the purpose of isolating potential net regional productivity gains to accommodate their needs.

In lieu of a statistically valid sample, a satisfactory preliminary estimate of student off-campus spending might be obtained using university financial aid tables. In the table below, for example, university and non-university expected average costs for Iowa State University can be discerned for undergraduate and graduate students. Analysts can attribute room and board costs for off-campus students to the general economy. All students' other personal expenses can be allocated across retail, service, utility, transportation, and service sectors in proportions reflective of the spending of young adults. Those expected proportions might be obtained from, for example, recent Consumer Expenditure Surveys produced by the Bureau of Labor Statistics, which describe consumption patterns of householders under the age of 25. While the use of financial aid templates is not based on a survey, it is reasonable to assume that university financial aid officials have strong incentives to adequately represent typical college attendance costs.

ISU UNDERGRADUATE STUDENT COSTS

	Resident	Non-Resident
Year	'09-'10	'09-'10
Tuition & Fees	$6,651	$17,871
Room & Board	$7,277	$7,277
Books & Supplies	$1,000	$1,000
Total University Expenses	$14,928	$26,148
Other Personal Expenses	$3,438	$3,438
Total Expected Cost of Attendance	$18,370	$29,590

ISU GRADUATE STUDENT COSTS

	Resident	Non-Resident
Year	'09-'10	'09-'10
Tuition & Fees	$7,565	$18,665
Room & Board	$8,550	$8,550
Books & Supplies	$1,000	$1,000
Total University Expenses	$17,115	$28,215
Other Personal Expenses	$4,175	$5,561
Total Expected Cost of Attendance	$21,290	$33,780

There is, however, no reliable short-hand method for estimating within-university and extra-university spending by non-student visitors to universities. Most modern universities have scores of camps, workshops, seminars, conferences, cultural events, and athletic activities annually. The attendances at these events are extremely diverse and discriminate. One would not, for example, sample attendees at one conference or workshop, and a handful of athletic events to then infer to the larger population of university visitors, but owing to the high costs of a comprehensive annual survey, that is often the type of "snapshot" survey employed for estimating the regional value of visitor spending. Such shortcut measures cannot be generalized to other population groups, and should not be used to infer the economic impact of visitors.

Extra-university spending can constitute a sizable component of the direct and indirect contribution universities make to regional economies.

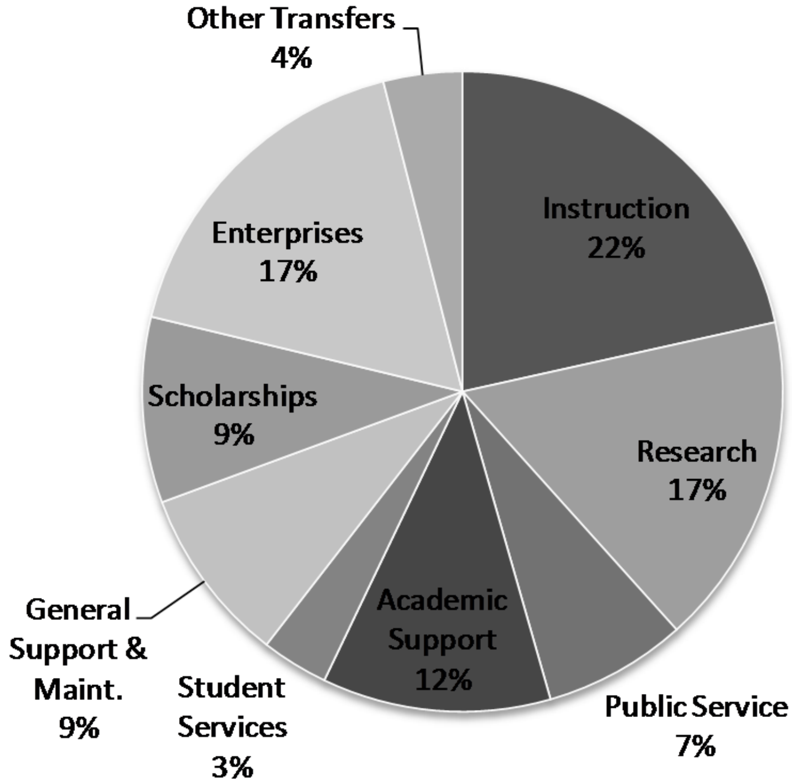
- Have the researchers employed procedures that distinguish between student on-campus and off-campus spending,
- Have researchers controlled for student spending in a manner that does not double count student spending with all university spending, and
- Have researchers used defensible and statistically reliable methods to estimate the economic value of non-student visitorship to the region?

Allocating Spending and Personnel Across Different University Functions

Universities are complicated entities that have a variety of core missions. They exist primarily to educate students, as a venue in which scientific and social research take place, as an environment conducive to artistic and literary expression, and as service centers for communities and for states. Universities also operate enterprises like athletic programs, events centers, academic and sports camps, housing and food services for students, and retail and services geared towards student and staff needs.

The accompanying graphic below displays Iowa State University spending proportions for the 2009 / 2010 academic year. With a budget of slightly more than $1.0 billion, instruction and general academic support constituted a combined 34 percent of spending. Enterprises like student housing and other revenue-generating activities and research, which also generate revenues, likewise constituted 34 percent of spending. Scholarships, 9 percent of the total, are university expenditures that translate into student consumption of educational services; they can be considered university payments to students just as university instructors receive payments for their labor. Taken as a whole, analysts must be mindful that they properly classify university activities and consider a university as a multi-faceted organization with many different parts as opposed to an amorphous higher education or research entity.

It is often the case that general university operations for instruction, academic support, public service, research, and overall general support and maintenance are identified as the core educational activities of a university. All activities that support students, such as student housing, dining, and other student supports might be categorically separated. Finally, a third general breakdown could consider all other revenue-producing enterprises, which would include athletics, university hospitals and clinics, and university centers for events and the performing arts.



Staff allocations across these categories can be problematical. University faculty members provide both instruction and research services. Scientists, service staff, and technicians may be engaged in university research or they may work in support of instructional activities. Non-faculty professionals may conduct both research and deliver public services as also may faculty, as would be the case with Cooperative Extension activities among the nation's land grant institutions. In all, it is quite difficult in many instances to attribute regional job or incomes gains to particular sub-sets of a university, though declarations of a university's sponsored research or outreach programs economic impacts are occasionally made.

When measuring a university's activities, it is useful to differentiate among its core educational activities, research and public service, its revenue-generating enterprises, and its health care or veterinary services (if appropriate) in order to properly allocate regional economic contributions and labor-related outcomes to specific university functions.

- Have researchers adequately described university expenditures in manners that suggest an awareness of the range of activities universities are engaged in, and

- Have researchers allocated university faculty and staff across those many functions to describe where the job and income-related outcomes of university spending are located?

Reporting Economic Contribution Outcomes

Standardizing the Reporting of Results

An IO modeling process or the application of a table of multipliers produces sets of tables, given the scenarios that were measured, that are not generally understood by the public at-large. University economic contribution analysts have two straightforward obligations in this regard:

1. They must present enough itemized detail so that the elements of the research can be scrutinized by reviewers, and

2. They must describe the findings in manners that align with conventional word usage for these practices, yet are done in ways that engender clear and common understandings of the results.

Impact modeling not only requires analytic deft, it requires linguistic precision. The total annual spending of a university, for example, constitutes the components of its output. Output is made up of all payments to suppliers of goods and services, whether procured within the study region or not, plus all payments to value added. Value added is mainly composed of payments to university employees or as payments in-kind in the case of scholarships to students, plus payments that take the form of profits to university enterprises, plus indirect tax payments that may occur as a result of university activities. Value added is a preferred method of reporting the net value of economic activity as it is exactly the same value as gross domestic product (GDP), which is the standard measure of total economic activity in a state on an annual basis.

At a minimum, reports of the findings should describe a university's direct economic activity, i.e., all university output, payments to labor income, and total jobs, as well as, via the modeling process employed, the total outcomes (or economic contributions) for output, value added, labor income, and jobs. Total economic contributions are compiled thus for every category measured, output, value added, labor income, and jobs in the form of:

- Direct activity (at the university level only)
  Plus
- Indirect activity (purchases from regional suppliers)
  Plus
- Induced activity (which occurs when workers spend their paychecks on household needs)
  Equals
- Total economic value

The following table lists the components of a standard economic contribution analysis for all Iowa public universities and community colleges and its university hospitals and clinics.[6] A straightforward explanation of the findings would read like this:

All publicly funded higher education and university health care spending in Iowa in fiscal 2010

[6] Swenson, Dave. Measuring the Total Economic Value of State-Funded Higher Education in Iowa. Department of Economics, Iowa State University. April 2011.

was $4.42 billion.[7] In producing that output, 59,824 employees were paid $2.48 billion in labor income. Higher education in Iowa required $1.19 billion in Iowa-supplied inputs to occur, which in turn supported 10,288 jobs making $415.7 million in labor income. When the workers in higher education and those in supplying sectors converted their labor incomes into household spending, they induced $2.19 billion in additional output in the Iowa economy, which in turn required 21,793 jobs making $717.2 million in labor income. Combined, Iowa higher education and health delivery explained $7.8 billion in industrial output in the state, $4.65 billion in value added, $3.61 billion in labor income, and 91,906 total jobs.

[7] This represents total, audited spending levels by the institutions, and comes directly from the published report for Iow. The actual total industrial output for these institutions, however, is lower than the amount reported in the table as wholesale margins, not total wholesale expenditures, were modeled as precious few of the manufactured goods our universities require (via wholesalers) are in fact manufactured in Iowa. Total expenditures, however, for the state's public universities have been reported in this table because the author of the study, me, is unwilling to explain to university administrations why total university spending does not equal total university output. Accordingly, the actual output multiplier is slightly higher than what is reported in this table. The value added, labor income, and jobs multipliers are, however, as modeled.

Total Economic Contributions of State of Iowa Institutions of Higher Education, 2009/2010

	Direct	Indirect	Induced	Total
Total Output $	4,415,100,283	1,190,990,798	2,189,380,637	7,795,471,718
Value Added $	2,738,575,793	616,840,939	1,292,962,847	4,648,379,579
Labor Income $	2,477,488,034	415,733,756	717,160,910	3,610,382,700
Jobs	59,824	10,288	21,793	91,906

This table also allows us to discern line-item multipliers. Multipliers are simply the total value divided by the direct value. Higher education spending in Iowa has an output multiplier of 1.77 ($7.795 billion ÷$4.415 billion = 1.77), which means that every $1 of higher education direct spending links to $.77 in indirect and induced activity statewide. The value added multiplier of 1.70 ($4.65 billion ÷ $$2.74 billion = 1.70) means that every $1 of value added paid by Iowa's higher education institutions results in $.70 in value added accumulating in the rest of the economy. The labor income multiplier of 1.46 ($3.61 billion ÷ $2.48 billion = 1.46) means that for every $1 in labor income that is paid to higher education employees, $46 in labor income is supported in the rest of the Iowa economy. Finally, the jobs multiplier of 1.54 (91,906 ÷ 59,824 = 1.54) means that for every job in Iowa's higher education system, 54/100th of a job is supported in the rest of the economy.

These are all very typical multipliers for regional or statewide higher education activities. Reports of multipliers for output, labor income, or for jobs that are higher than, say, 2.0 are highly unlikely in most economic regions and should be scrutinized cautiously.

The previous table was produced from IO models for the state of Iowa that were built specifically to accommodate characteristics of its higher education institutions and health care delivery. It is frequently the case, as would happen when using RIMS II total multipliers, that only direct and total economic contributions will be described, where the difference between the two would equal the sum of indirect and induced activity. As an inherent limit to that type of modeling, reviewers must be satisfied with that restricted level of detail, but it must be noted that in so doing, one would not know how to divide up impacts between suppliers to the university, the indirect effects, and suppliers of household goods and services to all affected workers, the induced effects. Both pieces of information have policy relevance, and as is always the case with public policy-related research, more information is to be preferred to less.

Clear and concise reporting of IO modeling or other estimation procedures is critical to conveying an accurate understanding of the economic contribution of universities to regional or state accounts.

- Are the findings presented in a manner that allows a reader to distinguish among the components of economic activity attributable to the university, and

- Do the results and the resulting implicit or declared multipliers make sense in general?

Appropriate and Inappropriate Characterizations of the Findings

This paper has already discussed the difference between measuring the total economic contributions our universities make in our state or regional economies and the estimated economic impact our institutions make. The economic impact occurs as we segregate activity that is exogenously demanded or funded, and via the modeling process conclude that it explains net gains in our regional or statewide economic accounts – that "but-for" the activity described, the state or regional economy would have been smaller. It is therefore not correct to claim that the total economic contribution of a university constitutes its economic impact. As it is absurd to consider a university as a "with or without" element of one's economy, it is just as erroneous to analytically pretend university economic activity is ostensibly in jeopardy of vaporizing when describing findings and imputing its value.

Analysts are also advised to not get caught up in the imprecise use of conventional social or financial measures that in fact have well defined and restrictive meanings in public and private finance. For example, some analysts have attempted to divide the total economic output of a university considering all linkages to suppliers and university staff's household spending by the state funding to arrive at a gross "return on state investment" (ROI) ratio. These are to be frowned upon and are considered most vulgar in their application. Gross economic output is not a "return" in any respected sense of the word, it is simply and only the identified pattern and amount of spending directly and indirectly attributable to a university. Second, state funding is not an "investment," in a financial sense; the term is used colloquially and often indiscriminately to infer robust returns to taxpayers.

General state funding is the use of tax-payer money to provide a wide array of public goods that have intrinsic social, economic, cultural, and human capital value. We do not invest in court services, law enforcement, prison guards, highway patrol officers, or clean air and water in hopes of a tangible financial return relative to outlays. These spending categories are classified, in the main, as public goods that do not have, as measured on a gross basis, market-based values. Nonetheless, promoters of universities (and state legislative funders) have become fond of the "investment" term, despite its inaccurate application to the situation that was evaluated. An investment means that we expect a monetary return that can be utilized in lieu of our original payment. The ostensible return that is claimed, gross output, is not available for state government and its citizens to use to purchase an equivalent amount of public goods. Accordingly return on investment jargon distorts and misleads supporters, citizens, and legislators.

It is also the case that state support of higher education is said to be leveraging external funds. This claim is analogous to the ROI implication. For example, state support of higher education does not leverage tuitions or federal grants in that an increase in state funding, for example, would lead to an increase in either. This causal characterization of state spending is fanciful and self-flattering, but inaccurate and should be avoided.[8]

Here is another reason why: universities are staffed with economists and finance professors who teach students about markets, investments, risk, and returns. The profligate use of ROI-type descriptions undermines the credibility of universities, most especially regarding the ability of faculty to validate such assertions, in light of the content of instruction delivered to students, and in light of prevailing practices in the private sector.

Another common misuse, analogous to ROI, is to imply a benefit-to-cost outcome due to university activities or services. In conventional and well-established government evaluation language, benefits have a defined meaning as to costs. Economic benefits are agreed-upon, quantifiable, and tangible enhancements to general social well-being as a result of public spending over an extended period of time. By its very nature, there are enhancements to net social productivity attributable to institutions of higher education – education is positively and strongly correlated with higher lifetime earn-

[8] It has been the case in Iowa over the past 10 years that state funding as a percentage of total university spending has declined persistently. Perversely, then, the lower the state's contribution, the higher its "leverage" of all other funds. It takes an extraordinary mangling of the English language and financial terminology to imply that this is a desirable outcome.

ings, high levels of productivity for longer periods of time, and far lower levels of lifetime social costs. By its very nature there are enhancements to net social productivity or well-being attributable to public health spending, as well – vaccinations, for example, are positively and strongly correlated to longer and healthier lives. Just as we can quantify the benefits of public health programs vis a vis the costs, we can do much the same for elements of higher education.

Benefit-cost analysis is, however, an activity that is completely distinct from economic impact assessment. Economic impact studies look at the value of sets of institutional, student, and visitor activities within a circumscribed economy on, typically, an annual basis. Benefit-cost analysis is much different. It measures the value of increments to consumer or producer surpluses (benefits) over a long period of time that are meaningfully linked to discrete sets of publicly funded activities (the costs). Generally, when we have a mature system of public goods delivery, we measure benefits and costs on the margins; i.e., changes in benefits attributable to changes in costs for a particular aspect of new or revised programming.

Stated simply, benefit-costs analysis and economic impact or economic contribution analysis are two completely separate measures of the worth of institutions of higher education. The multiplied-through output, value added, labor income, and job outcomes are not benefits within the restricted meaning in government decision making, and characterizing them as such is inappropriate.[9]

Finally, an ersatz benefit-cost conclusion is sometimes implied regarding fiscal outcomes associated with university economic contributions. Measures of university economic contributions will occasionally include estimates of state government tax revenues that would be associated with the incomes that are directly and indirectly supported by university operations and other activities. Next, analysts compare those gross state tax receipts to taxpayer support for the university, implying that the university and all of its related activities in fact fully or significantly reimburses the state for its support. As state taxes that university-supported householders contributions to state accounts are in fact used to pay for the entire range of state goods and services demanded by those households, to infer full or even significant taxpayer repayment is highly misleading.

Economic contribution analysis should use standard and straightforward language to describe the findings, and should forgo the use of private investment jargon when describing university values.

- Do the consultants lapse into discussing the return on investment or the leveraging value of state spending,

[9] For an excellent discussion o f the difference between benefit cost analysis and the determination of value added gains as they relate to input-output analysis protocols and interpretation see: Cooke, Stephen C., The Problem: Using Value-Added Information in Benefit/Cost Analysis. In Otto, D. & Johnson, T. (eds), Microcomputer-based Input-Output Modeling. Westfield Press. 1993.

- Do the results improperly claim that state taxpayers, in essence, have been made whole in that university relative economic impacts generate more than enough tax revenues to cover state support, or

- Are annual economic outcomes described in a manner as to inappropriately imply net-beneficial gains to social welfare?

Properly Conveying Spillovers and Other Beneficial Transfers

IO modeling and tables of multiplier analysis explain the value of all inputs into service delivery plus payments to labor, capital, and the rest of the world. The models and the multiplier coefficients explain economic activity from the university level through all of its backward linkages, or what is sometimes called up-stream activity.

IO models do not measure downstream activity or forward linkages, but it is frequently the case that universities attempt to justify their existence through such declarations. It may clearly be the case that university influences result in spinoff industries, research parks, enhanced regional entrepreneurship among faculty or graduates, or create the conditions for significant quality of life improvements within the primary region that they serve. Attributing those values to universities, however, is a dicey prospect no matter how well-connected universities are to their external economies.

How do you measure and quantify in income and job terms the spillover of R&D knowledge into other disciplines, the private sector, or the community at-large? Can you apply a "but-for" condition to declare with quantified certainty that some economic activity would not exist were it not for its proximity to that specific university? And even if linkages are clear cut, a non-university enterprise is accounted for in the economy separately. If I am an entrepreneur and I am successful because of my education or some other creative interaction with a university, the success I have is mine, not the university's. I realize the income, I realize the losses, and I pay the taxes on the profits. Furthermore, were it the case that two university engineering graduates started a solar film firm on the edge of the host community, for example, can a university claim any more credit for their success than their respective high school chemistry or physics teachers who first excited their interests in applied science?

Measuring the lifetime benefits of higher education to individuals and society is a different story than the elementary quantification of basic economic activity supported regionally by a university, its students, and patrons. While there is ample scientific evidence of the importance of higher education and overall life quality, it is quite hard to pin a precise number on its value and then apportion values to specific levels or types of development. Much of the worth of a higher education is intangible. Absent other measures, economists occasionally measure individual, lifetime income additions from higher education. They approach the question by analyzing earnings differentials for individuals with a college degree vs. no college degree, while trying to control for other factors that influence career path decisions and earnings over time such as choice of major and occupation, to name only two. Last, they discount the value of the lifetime earnings differential into present value terms to arrive at a total lifetime benefit assumption relative to costs, which are both summarized as present values.

But assigning some portion of the value of education to a single university can be problematical. Beyond the important scientific need to be able to control for earnings differentials explained by your personal characteristics and life choices after graduation is the added challenge of controlling for earnings differentials attributable to your choice of institution. In other words, we must consider the opportunity cost of not only not attending a college at all but also not attending a different college or university. In addition, how would we apportion the values to an undergraduate college and a graduate college? This is a very imprecise and vague process.

Properly done, these measures would require an experimental design that randomly assigned individuals to various educational "treatments," which of course is impossible, or a massive random survey of the universe of college graduates (still living) with sample sizes sufficient to allow for controls across institutions, which would be cost-prohibitive. Without this information, any attempts to assign to a single institution a share of its graduates' lifetime earnings differentials would be a highly subjective and dubious exercise. The potential for gross mis-measurement and mis-statement makes the criticisms of traditional university economic impact studies pale by comparison.

An oft-stated objective of university administrators is to develop credible measures for their universities' contributions to regional economies and its alumni's life-long prospects. If the value of higher education is not already obvious to the intended audiences for these measures, flimsy and credulity-stretching downstream or lifetime economic well-being arguments will not advance university public relations objectives.

There are knowledge and other intangible spillovers emanating from all universities. Universities may create the conditions for entrepreneurship and enhanced regional productivity; however, measuring those regional gains or the lifetime worth of university attendance is difficult and highly imprecise as is apportioning such measurements to particular institutions.

- Has the study attempted to impute "downstream" economic activity with the assumption that there is clear and convincing causality between university activities and spillover regional growth, or

- Have university researchers attempted via measures of lifetime earnings and other measures to differentiate themselves from some alternative?

Measuring Clearly University-Linked Entrepreneurship

There are two other areas that represent "easy pickings" in terms of claimed economic development activity that attaches to a university. The first is the very popular business incubator components of many universities. Second, we must not overlook the tremendous productivity of university faculty and scientists as participants in the private sector.

Many universities have quasi-public attachments that interact continuously and meaningfully with their research staff, their student talent pool, and the overall economy. At ISU, for example, there is a research park that contains a wide array of both publicly funded and privately supported activities. Some of these may have just a couple of staff members and no discernible product line besides intellectual output. Others have distinct and valuable products or services. Still others are, for lack of a better term, incubating in hopes of developing marketable ideas, goods, or services in the future.

The value of that type of university-sponsored activity to the regional economy can certainly be measured using standard IO methods. One may discern the size of the firm in terms of workers, the levels of compensation, and the kind of economic activity in which they are involved. It is then possible to describe the firms as spatially linked, but not functionally integrated businesses and institutions, existing on the literal and figurative edges of the university. And it can be argued that "but-for" the university's support and resources, the firms might not exist regionally or at all. The firms will have multiplied through impacts in the regional economy as they will require inputs, their workers will convert their earnings into household consumption, and there will be enhancements to the regional economy as a result. All of this can be measured using proper IO modeling procedures.

This is important, however: the firms are private operations. The profits return to the owners, and their annual operating expenses are distinct from the host university. Their values may be reported, but they must be reported separately from and not added to general university estimates.

In the long run, we would want to know how many succeeded, and in what forms, as well as how many failed. Ultimately, we would want to know where enhanced productivity in these firms accrued. If it started small in Iowa and became a giant in Portland, then the benefits of that economic activity get counted in Portland, not Iowa. Apportioning that growth back to the university is not only a stretch, it is simply inaccurate and misleading. But there is nothing at all wrong with well-documenting that type of success as well as others as concise case examples of a university's impact. In fact, well written case examples are far more likely to engender confidence in university activities than economic impact declarations.

Along similar lines, a large fraction of faculty and scientific staff at universities are consultants, sole business proprietors, or have significant ownership stakes in private businesses. Those enterprises constitute pure entrepreneurship, may involve a tremendous amount of university-related technology transfer, often contain the application of intellectual property that might have been nurtured and developed within the university, and may involve new product or service commercialization. The value of that tacit partnership of the university with its talented staff is something that has rarely been measured formally or reliably, and doing so would be difficult, as consulting activities are usually only monitored insofar as conflict of interest rules apply.

Still, a university could survey its faculty and staff to discern the range and value of their private enterprises, as well as the extent to which those enterprises were a direct offshoot of their university positions. A properly drawn sample could yield enough data to allow universities to document and describe the activities, and to even infer the total value of such sales on an annual basis. And where the research conducted properly, it might be possible to produce a declaration of the economic impact of that entrepreneurship.

A better approach to dealing with all manner of spin-off, incubators, or staff entrepreneurship, however, would be a systematic investigation of the ranges and types of activities. A proper documentation of business or product development, consulting activities, or innovative applications using a case-study approach to investigate extra-university economic gains is likely to be much more preferable to an elementary declaration of economic contributions using modeling methods.

The upshot of such an approach is that it would allow investigators to document the depth and scope of activity and provide the public and policy makers with meaningful examples of university-linked regional successes. The downside, given modern policy making preferences, is that a case study approach does not provide the “large number” bottom line that many policy makers have become accustomed to.

University-linked incubators and business development centers are private ventures that tap into university services, talent, or knowledge spillovers. Similarly, university staff entrepreneurship produces a wide array of products, services, and contributions to regional economies.

- Have universities attempted to fold in private economic gains into their declarations of regional economic worth, or
- Have universities attempted to appropriate the value of staff entrepreneurship as a tangible output of the university?

Concluding Discussion

This report does not deal with all of the issues that may arise when compiling university economic impact analyses. University capital spending, for example, tends to be lumpy in nature, and begs consideration of how to treat periodic improvements and expansions of university capital stock when evaluating university economic contributions. Capital developments that are significantly underwritten by donations imply regional economic gains that are different than taxpayer funded development.

There are other tangible and intangible values of university activity that we do not measure, not because they are immaterial, but because the activity is simply difficult to account for. Students are incredibly energetic and engaged in their host communities, and student groups conduct a wide range of philanthropic activities. Students, staff, and faculty donate their time to a broad array of social needs. All of these examples are important, all are very valuable, and they should be described as well as they can, but they do not lend themselves well to economic impact evaluations.

A general standardization of university economic impact studies will allow for more reliable determinations of their worth, enable the legitimate comparison of institutions with one another, hopefully empower both producers and reviewers of such research, and should enhance public and lawmaker confidence in university promotional activities.

University economic contribution studies are not exotic or inherently difficult measures. There is a great body of literature describing proper procedures for conducting input-output-based studies. There are, however, many examples of studies that do not acknowledge those standard procedures or proceed in manners that discount or disregard established measurement protocols, to include the generally understood limits to this type of analysis. Re-attaching this university economic contribution research and evaluation to its academic and procedural heritage may help to re-establish a viable baseline from which all public higher education institutions can be properly evaluated and described in the future.

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The Settlement of San Francisco and the Land Use Changes in the San Francisco Bay Area

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Introduction

Many of the farmlands, wetlands, forests, and deserts that formed the "initial environment" of America have been transformed into human settlements. Most major metropolitan areas face the growing problems of urban sprawl, loss of natural vegetation and open space, and a general decline in the amount and quality of wetlands and wildlife habitat. Cities have changed from small, isolated population centers to large, interconnected economic, physical, and environmental features. One hundred years ago, approximately 15% of the world's population lived in urban areas. Today this percentage is nearly 50%, stressing ecological and societal systems (USGS).

The San Francisco Bay area has a great history and is today one of the main urban regions in the United States. Its access to the Pacific Ocean, its intense seismic activity, and its unique location has changed the landscape and the use of land, making it particularly suitable for study.

In this paper, we report on the interactions between the city of San Francisco and its surrounding environment throughout the stages of development of the area. Both sides of the interactions will be studied; the impact of the urbanization process of San Francisco on its surroundings and areas further removed from the city, and, vice versa, the impact of San Francisco's surrounding areas on the growth of the city itself.

Population data, timelines of historical events, and related information will be used to explain the land cover and land use changes. The original land cover and land use will be studied as well as the changes that occurred through time. The geographical changes will be related to the socio-economic forces and to the changes in the society. The main factors of changes studied in this paper are; (1) population, (2) urbanization and transportation, (3) agriculture, (4) vegetation cover, and (5) water issues.

The Environmental Setting

The San Francisco Bay Area is a metropolitan region of 7.15 million inhabitants that surrounds the San Francisco and San Pablo estuaries in Northern California (2010 United States Census). This region comprises nine counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma), and consists of urban (San Francisco, Oakland, and San Jose) along with rural areas (See Figure 1). The Bay Area represents 4.4 million acres (excluding bay waters and large lakes) and in 2000, 16% was developed for urban use. San Francisco is the most urbanized county, and Napa the most rural (Focus).

The landscape of the Bay Area hosts a greater variety of rocks than most regions in the United States, due to the geological setting along the western margin of the continent (USGS, 2002). The region has also considerable vertical relief in its landscapes, along the western border of the peninsula, and on the eastern part of Oakland (See Figure 1). This region is particularly exposed to hazards due to several factors; (1) the numerous major active faults, (2) the poor soil conditions near the Bay, (3) the large urbanized areas of filled marshlands and bay mud, and (4) the coastal location that makes the region vulnerable to Pacific Ocean tsunamis.

Overall, the region has a Mediterranean climate. One of the climatic features of the Bay Area is the prevalence of fog that provides some moisture during the dry season (USDA, Weather Bureau, 1913).

The San Francisco Bay Delta Estuary is the largest estuary on the West Coast of North America and covers an area of a little more than 400 square miles (EPA). It provides drinking water to 25 million Californians, and irrigation to 4.5 million acres of agricultural land. Despite its urban and industrial character, the Bay Delta ecosystem supports 750 species of plants, fish, and wildlife, including several endangered and threatened aquatic species (EPA). The few remaining salt marshes provide key ecosystem services such as filtering pollutants and sediments from the rivers. The main vegetation is the chaparral and oak woodlands. In addition, grasslands prevail in some lower elevations, and patches of pine are found at higher elevations (USDA-NRCS, 2003).

California landforms determine drainage, soils, and natural vegetation. They also influence where man lives, what he does with the land, and what kind of transportation and communications he has. The environmental settings have a direct impact on the land use and land cover of the area.

History of the San Francisco Bay Area's Urbanization

Pre-Hispanic Period

Native Americans have lived in the San Francisco Bay Area for thousands of years. At the present time, the best estimates of the size of the Indian population in the San Francisco Bay Area in the 18th century (before the first Europeans arrived) is approximate 20,000 people (Kirtland, 2010). The population was clustered along the Coast, diminished toward the interior, and dropped rapidly after crossing the Coast Ranges. The lower courses of large streams, particularly those running through the foothills of the Sierra Nevada, were the exception with higher population densities than the surrounding areas (Hornbeck, 1983). The Natives did not develop exploitive techniques to significantly alter the environment in their favor; they appear to have developed adaptive rather than exploitive responses to the environment (Hansen, 1973). The lack of development of agriculture-based civilizations is likely the main reason why the Indians showed little interest in the Spanish settlers for several centuries (Hayes, 2007).

The relationship between population density and distribution, settlement, territorial organization, and subsistence was very closely related to the local environment.

The Hispanic settlement (1769 - 1846)

The early Spanish exploration and the eventual settlement of California were not isolated undertakings; they were part of an ambitious settlement scheme that was to extend from the Gulf of Mexico to the Pacific Ocean. Spain's interest in California came from the need for a port to develop the highly profitable trade with the Philippines (Hornbeck, 1983).

The entrance to the Bay was found in 1770 by Pedro Fages and in 1775, an extensive nautical survey to map the Bay was undertaken

(Hayes, 2007). The Spanish colonization was centered on three institutions; the mission, the presidio and the pueblo, each with a specific role and location. Presidios were located on the coast for defense purpose, pueblos were located on places for permanent settlement and agricultural development, and missions were located in areas that contained large numbers of Indians (Hornbeck, 1983).

Since the Native Indians had very few agricultural skills, crop production was very low. However between 1780 and 1800, the annual harvest of staple crops (wheat, maize, and barley) greatly increased. By 1815, most missions had completed an irrigation system to deal with the semi-arid climate (Hornbeck, 1983). Abundant pasture, a mild climate, and available water allowed mission livestock (primarily cattle) to increase substantially.

After 1821, the Mexican Republic obtained all rights to the public domain and opened California to trade, passed new colonization laws, and secularized the missions. California residents, along with new immigrants (mostly Anglos from the United States and England) began to take advantages of Mexico's colonization laws. By 1840, the rancho (land to graze cattle around the presidio) had become the predominant settlement pattern and the most common way to acquire land (Hornbeck, 1983).

The system of Mexican land grants was one of the most important influences in Californian history. It led to the concentration of land ownership in a few hands. Land ownership became one of the major points of hostility between Native Californians and new settlers. Heavy immigration combined with different mapping systems and uncertainty about the validity of Mexican land titles contributed to the resentment felt by both groups. The Mexican grants were conditional, boundaries were vague and overlapping, legal titles were faulty or did not exist, and the existence of many fake land claims made the valid ones look suspicious. To settle this complex problem, the Land Act of 1851 established a land commission (Hayes, 2007). In fact, many of the large farms and ranch properties today originated in one or more of the Mexican grants. City streets and country roads often follow the boundaries laid down by Mexican land grants (Beck, 1974).

With the more intense opening of California, it was expected that new traders and settlers would arrive and expanded settlements would result. However, the east shore of the bay offered at first no good landing points, while the shores towards the sea were not easily accessible (Curti, 1968).

The Hispanic settlement was the first step in the San Francisco Bay development. By bringing Mexican, Spanish, or Anglo migrants, and by opening California to trade with the Pacific lands, it directly links San Francisco to its international and national environment. On the other hand, the growth of San Francisco happened in a local context with the development of livestock agriculture for the subsistence of the migrants, and with the Mexican land grants that shaped the organization of roads until today.

The American California (1848-1875)

The discovery that led to the gold rush was made by James Marshall on January 24, 1848 in Central California. The population increased tremendously and the urbanization of the region started (Godfrey, 1997). This large migration to California is often said to be the largest movement of people to one area on the North American continent. However, topographic barriers inhibited movement into, and the settlement of certain areas. In addition, California's long summer drought prevented much of the interior land from being permanently settled until new crops and farming methods had been developed, along with the use of irrigation

(Barth, 1975). Moreover, the frequent fogs and nearly constant winds over the sandy hills did not facilitate the settlement of American newcomers (Barth, 1975).

In San Francisco, at the time of gold discovery there were only 820 inhabitants. Four years later the population had increased to 35,000 inhabitants. For a decade, the city remained the single great metropolis of the Far West and actually the one significant harbor of the Pacific Coast. Then, the harbor became the backbone of the state economy (Curti, 1968). The vast majority of the gold seekers was from the United States and came by three principal routes: around Cape Horn, across the Isthmus of Panama, and overland through the Oregon Trail.

As in so many other areas, the Gold Rush provided the first great input towards the development of roads, the growth of freighting and express companies, and the emergence of a stage coach system. Before express and stage coach lines could flourish it was necessary to build bridges and roads. By 1860, the state was knitted together by a system of passable roads with their center in Sacramento. Initially, most of the roads were of private construction. Not until 1859 did the state appropriate much money for roads (Godfrey, 1997).

San Francisco was the landing point for all great ocean ships and also the unloading place for the goods that were destined for the interior and also for those that were brought to San Francisco for export by the waterways from the interior.

By 1875, the Pacific Coast's major metropolis had emerged with truly urban contours. As the largest city on the Pacific Coast, San Francisco benefited from the economic activities of the region; mining, agriculture, fishing, timbering, and so forth. By 1875, only 25 years after the Gold Rush, the center of San Francisco was densely build up and subdivided into distinct financial, wholesaling, and retailing areas. At that time, further expansion of the city was limited by the irregular topography, the close waterfront, and the nearby residential neighborhoods. The entrance to San Francisco Bay interrupted the extension of the coastline to the north (Barth, 1975). By 1890, the population in San Francisco was near 300,000. (Census of Population) At the time, it was the eighth largest city in the U.S.

The Gold Rush directly impacted the development of San Francisco Bay Area by bringing new settlers. This event also impacted the local environment with the construction of roads and railroads, and affected the local and international economy. However, San Francisco is surrounded by steep relief, and therefore the growth was slowed down.

The earthquake of 1906 and reconstruction of the city (1910-1930)

The San Francisco earthquake and fire of 1906 remains the most spectacular disaster of the history of the state (Hornbeck, 1983). The earthquake destroyed some 5,000 buildings, twisted roads, railways, sidewalks, gas water, and electric lines in useless shapes (NOAA, 1906), while the fire destroyed a third of San Francisco (Hornbeck, 1983). The fire lasted several days because the population had no easy access to fresh water, the bridges and the Hetch Hetchy dam were not built yet (NOAA, 1906).

However, after 25 years of subsequent rapid rebuilding, this event gave rise to a new San Francisco. The centralization of business activities resulted in renewed pressures for high rise development in the newly expensive downtown. The financial district spread into adjacent land use areas; the warehouse district shifted southward and the retail district migrated westward.

Between 1920 and 1940 metropolitan San Francisco-Oakland remained the major center of population. Interurban electric streetcar lines and railroads with commuter service traversed much of the area, with direct routes into San Francisco from the Peninsula to the South and with ferry connections North and East across the Bay. The Southern Pacific Railroad was primarily the reason for much growth on the bayside flatlands between San Francisco and San Jose. Just before 1940 the two transbay bridges brought new suburbs within easy commuting range.

In this post-disaster period of time San Francisco got connected mostly to its local environment. The economic activities became centralized, and the transportation system developed.

Post World War II: Modern medium-rise city (1950-1985)

During World War II, San Francisco was the major mainland supply point and port of embarkation for the war in the Pacific (Hornbeck, 1983). After World War II local freeway or expressway construction begun, linking suburbs to San Francisco even more directly. These modern roads were built in an attempt to reduce travel time, but resulted in a population expansion in the area, and encouraged the development of several sub centers (Young, 1957).

Between 1940 and 1955 the population of the San Francisco Bay Area increased from 1.7 million to 3.2 million. An ample salt water harbor with sea level access to the Central Valley gave this area an advantage, which has been an important factor in its growth and development (Young, 1957).

During the 1950s, despite the tendencies toward suburban development, the urban core of the Bay Area was still San Francisco-Oakland-Berkeley. However, there was no longer sufficient space to absorb the population increase, particularly since the new residents seemed to prefer low density housing. The new urban development followed two patterns; a growth southward from the main centers along major transportation routes parallel to the bay, and an additional centrifugal expansion from the major subcenters. One of the patterns was also the change over from orchards and other agricultural uses to residential subdivisions made possible by a dense network of paved roads originally build to serve an intensive horticultural demand (Young, 1957). This last pattern had a detrimental effect on the remaining agricultural activities.

Before World War II the employment was based on food processing, shipping, and financial activities. Shortly after the war, basic heavy industries expanded sufficiently to affect the total economy. Altogether the number of added plants in the Bay Area between 1950 and 1955 totaled 665 and the number of expanded facilities was 2022 (Young, 1957). The development of these industries had consequences; the increase of the labor force led to a high land demand for industrial expansion and for residential use (See Figure 5). This industrial development was confined mostly East and South of the Bay on the flatlands, and with a natural focus for water and rail transportation facilities.

From 1950 to 1955, there was an estimated net population increase of 375,000 in the nine counties of the Bay Area. San Francisco appeared as a new city with a contemporary skyline. The growing importance of foreign trade and investment has favored the development of global centers. The new downtown was symbolized by new tall buildings, however not as tall as in other city, due to the intense seismic activity.

Between 1965 and 1982, the San Francisco downtown (1.6 square mile) has more than doubled its office space to 60 million square feet. With all other land uses, the total building space exceeded 102 million square feet (Godfrey, 1997).

The Bay Area physical geography separates the areas of development. Regional demographic, economic, and transportation trends all provide bases for the decentralization of the San Francisco Bay Area. The population kept increasing in the Bay Area but the regional share of San Francisco County was dropping while the South Bay Counties (San Mateo and Santa Clara) on the other hand were booming.

The decentralization was demographic and economic. To cut costs, major corporations relocated thousands of lower level jobs to “back offices” in suburban areas in the 1980s. Overall in the 1990s San Francisco had become less central to the Bay Area, as business relocated to the suburbs and the electronic industries of Silicon Valley boomed.

In this period of industrialization, San Francisco city had different links and impacts on its environment. The industrialization brought a population and economy decentralization, also favored by the development of the diversified transportation system. San Francisco also became connected with its international environment by becoming a global center.

Land changes by thematic foci

Population changes

From a Hispanic population of 14,000 in 1848, California has grown to the most populous state in the United States, with some 37 million inhabitants in 2010 (U.S. Bureau of the Census). In the Bay Area, the highest rates of population growth were found during the 1900s and the 1920s, with respectively 41% and 33% while the population growth rate is decreasing since 1950s (see Figure 2 and 8) (U.S. Bureau of the Census).

In 1860, the year of the first census, over half of the state’s residents were located in the Sacramento Valley or in nearby gold bearing Sierra Nevada. Another 30% were located in the San Francisco Bay Area. Population shifted dramatically during the gold era rush, with some communities becoming metropolises of more than ten thousand people. Until 1900, the San Francisco Bay Area represented more than 40% of the total California’s population. Since then, this rate kept decreasing and today, it represents less than 20% (U.S. Bureau of the Census).

Urban growth and transportation

<u>Urbanization</u>

California had developed a large urban population by the 1850s, in part because towns played an integral role in early Gold Rush settlement. In the 1860s, 20% of California’s population lived in towns of more than 2,500 people (See Figure 7) (Hornbeck, 1983).

The technological development of the area was shaped by the particular topography. In the early stages of the Gold Rush most miners recognized San Francisco as a center of exchange and trade. In the decade of the 1870s, towns grew in size and number and an integrated network of towns emerged. California’s early urban growth is explained by the availability of job opportunities in and around San Francisco, particularly after the completion of the transcontinental railroad, which encouraged development of nonagricultural activities such as retailing and wholesaling (Dowall, 1984).

Urban technology facilitated the rise of cities. At first the railroads, streetcars, cable cars, and ferry boats seemed to represent forces that would draw people together, but it was recognized that these new innovations made possible the separation of the home of the individual from his place of work. Technology had actually a decentralizing impact (Godfrey, 1997).

"Since World War II, the nine counties of the San Francisco Bay Area have experienced all the elements that add up to a suburban land squeeze: extensive land development, increasing use of growth management controls, more restrictive land use and environmental regulations, and a go slow development posture." (Dowall, 1984). Prior to the 1950s, development was primarily concentrated in the central Bay Area. The two central cities of Oakland and San Francisco accounted for more than 50% of the population of the nine counties. Agriculture was still the prevailing land use in the North and the South of San Francisco and in the East of Oakland. The only populous cities in the South Bay were San Jose and San Mateo. Shortly after World War II, the Bay Area entered in a period of rapid changes. Between 1950 and 1960, the Bay Area population increased by nearly one million, with much of its growth concentrated in southern Alameda, San Mateo, and Santa Clara counties (U.S. Census). The growth took place along the highways, and brought along industries. Between 1960 and 1970, the population grew again by nearly one million, with few cities untouched by this development (U.S. Census). Much of the growth was happening south of the Bay Area. Sonoma and Napa counties retained their agricultural character. The development of the Southern Bay occurred at an extraordinary pace propelled by fast growing high technology industry. By 1975 development had consumed nearly 50% of all the land in the Bay Area designated for development (Forero, 1992). Population had shifted to the South and East. The northern counties began to experience pressures to develop and shift from their traditional agriculture. In 1975, a detailed land inventory found that 350,000 of the region's 4.5million acres were vacant and developable (Hayes, 2007). However, much of the Bay Area's vacant land could not be developed due to its topography or sensitive environmental character.

The process of urbanization has worked to shape local land use policies. The historical pattern of centrifugal development introduced an entire new set of rural communities to growth pressures, as development spread eastward and southward. Communities began to feel substantial postwar effect such as traffic congestion, air pollution, and dwindling open space.

Transportation

The Bay of San Francisco exhibits one of the best natural harbors of the world, it is therefore no wonder that the first transportation means was by water. However, San Francisco Bay was, until completion of its two main bridges, an obstacle to transportation which prevented development of large sections and isolated the industrial centers of the East Bay from the financial district. The new unit created by the bridges assured a future much more intense and orderly development for all communities of the Bay region (See Figure 3) (Hansen, 1973).

The rapid increase in population due to the Gold Rush brought a wide range of demand for manufactured goods, tools, machinery, and food products which undeveloped local industry could not supply. During the 1850s, maritime commerce was very developed, and the rapid increase in shipping made necessary the immediate building of extensive piers and docking facilities. In 1863, the San Francisco and Oakland Railroad Company began running their train-ferry from Oakland Wharf to Broadway Wharf in San Francisco (Hansen, 1973). The great period of ferry transit reached its peak in the 1930s, when 60 million persons crossed the bay annually, along with 6 million autos.

In the years after statehood in 1850, some 200 railroads had been constructed in California. The state's first railroad was the Sacramento Valley line created in 1852. It ran from the Capitol in Sacramento to Folsom, and was only 22 miles long. On February 22, 1856 the first train operated. This railroad got extended in

1877 to Placerville. The San Francisco and San Jose railroad began service in 1864 (Rudolph, 2000).

Most Californians were more concerned about transcontinental railroads than with local lines. The Gold Rush triggered a rapid immigration necessitating a more effective link with the rest of the nation. The transcontinental line was completed in 1869. This connection changed the "Wild West" into an urbanized, industrialized economic and political area. The railroads helped establish countless towns and settlements, paved the way to abundant mineral deposits and fertile tracts of pastures and farmland, and created new markets for eastern goods (Rudolpf, 2000).

In San Francisco, public rail transit began particularly early with the introduction of cable cars in 1873. The cable car allowed land owners to develop land otherwise inaccessible with the steep slopes and localized real estate booms along cable lines (Hayes, 2007). The Twin Peaks Tunnel completed in 1918 allowed the San Francisco Municipal Railway to build a direct line from downtown to the Southwest, which led to the development of this area. In the East Bay, a streetcar line was constructed between Oakland and Berkeley in 1873. A San Francisco, Oakland, and San Jose Railway began service in 1903. The longest interurban in North America was the Sacramento Northern Railway that began in 1913, and was 93miles line from San Francisco to Sacramento (Hayes, 2007).

During the railroad time, only the Southern Pacific railroad leading to Los Angeles led directly to the city by land. All larger lines terminate on the East Shore. Between San Francisco and the East shore, freight had to be always forwarded at considerably high expense (Rosskam, 1939). Nowadays, several bridges span over the water of the Bay Area. The rise of the automobile and the completion of the Golden Gate and Bay bridges in the 1930s led to the slowdown of the streetcar, interurban, and ferries in the Bay Area. The Bay Bridge, leading towards the East from San Francisco was opened in 1936. The Golden Gate Bridge built in 1937 links San Francisco and the northern Counties of the Bay

In the time before increasing the general employment of automobiles, most settlements were small and compact because railroads, streetcars, and ferries were the sole means which offered transport, and people were forced to live near the traffic routes (Curti, 1968). By 1916, the era of mass automobile was underway. This automobile era was facilitated by earlier (1896) creation of state department of highways (Hayes, 2007). In San Francisco a dense network of freeways was proposed in 1948 by the city's planning department.

Agriculture

Prior to 1860, many settlers were attracted to the Bay Area by mining opportunities, and they were not prepared to become farmers. Agriculture was not easily established because a large proportion of land suitable for agriculture did not receive enough rainfall to support the crops with which the newcomers were familiar. In addition, preparing the farmland for planting required large amounts of capital, not always available to newcomers. Substantial plots of farmland along the coast were not available for settlement until the late 1870s because of unclear land titles from Mexico's rancho grants (Young, 1957).

In the early years following the Gold Rush, new comers followed the Mexican example and raise cattle. A shift to commercial grain farming began in the 1860s in response to the increase demand for wheat in Europe. The wheat boom stopped in 1910 (Young, 1957). The beginning of the 20th century marked a shift in California' agriculture from an extensive livestock grain farming to diversified, intensive specialty crop farming. With the completion of the rail network and the increase in population the transition from wheat to commercially viable specialty crops was possible (Forero, 1992). The transport accessibility was not an issue anymore, and the Californians could focus on more suitable crops (See Figure 4).

Today, California is one of the leading agricultural states. In 1980, California's farmers received 10% of national farm revenues (Hornbeck, 1983). California's physical environment represents a unique combination of soils, topography, and climate that have allowed farmers to take advantage of specific environmental conditions. In many cases crop patterns are determined by environmental conditions rather than by economic or market conditions. Solano, Contra Costa, Napa, and Sonoma counties are more agriculture orientated than the rest of the Bay Area.

The Bay Area has undergone some recent changes due to urbanization. The rangelands and non-forested lands that were used for livestock grazing are subject to increased demand for residential property (Forero, 1992). These lands provide not only a livelihood but a variety of public goods, including wildlife habitat, watershed, and open space. The competition for land is leading to crowding of livestock on remaining rangelands causing potential resource degradation. The East Bay rangelands illustrate the types of issues arising as California's rapid urbanization continues.

Control of the water supply has been an important factor in the rapid development of the San Francisco Bay Area. With limited precipitation, irrigation had to be developed for cultivated acreage to increase. Efforts to irrigate are as old as Spanish settlement. The American era brought rapid expansion of irrigation programs especially in the 1850s (Young, 1957). Today, more than 90% of the current cropland is irrigated (US Ag Census, California).

The San Franciso Bay Area's farms underwent changes in organization, management, and ownership. Many farms increased in size, focused on one crop and became incorporated. The land competition due to the urbanization leads to a decline in farmland acreage.

Vegetation Cover

The pattern of vegetation around San Francisco Bay before the first settlers was as follows; (1) Redwood forests along the coast, in the region of greatest winter rain and heaviest summer fog, (2) Grass and oak savannah, eastward of the Sacramento Valley and along the floors of the principal intermountain valleys of the coast Range, (3) Low growing chaparral in the interior ranges and in the dry southern slopes, and (4) Marshes and tule rushes fringing the Bay (Simpson, 2007).

Rapid growth in the San Francisco Bay Area, is accelerating air pollution, water, and energy demand problems (USGS, 1998). Changes have taken place in the outlines of three major types of vegetation. Much of the forest has been replaced by grass, brush, or crops; the early grassland is occupied by cultivated lands, and the former savannah was covered with a thick sod of perennial grasses and is now dominated by the annual wild oat (Hansen, 1973).

The urban environment in the area has rapidly expanded onto predominately rangeland and agricultural areas. The recent changes in the San Francisco Bay Area show a transitional conversion of more than 29,000 acres of shrub to grassland, followed closely by a conversion of 24,000 acres of cultivated land to grassland (Simpson, 2007). Increased population density translated directly into pressure to convert scrub/shrub, grassland, mixed forest, and cultivated land covers, to urban and transitional urban areas.

When forests, grasslands, and scrub/shrub are converted to low intensity development, such as residential neighborhoods, the impact to the affected land covers may be less because, typically, 20 to 50% of the vegetative cover remains in residential neighborhoods through the incorporation of large yards, parks, trees, and open spaces (Simpson, 2007). High intensity development, such as industrial parks, parking lots, and highways, impacts these areas severely because they are no longer predominated by vegetation; rather the landscape is dominated by buildings and paved surfaces. About 31,000 acres of combined forest, cultivated land, scrub/shrub, and grassland were lost to development during the period from 1986 to 1993 (USGS, 2007).

Water issues

The vast San Francisco Bay and Delta region of California is located at the confluence of the Sacramento and San Joaquin Rivers. The consequent land use changes, particularly urbanization, have resulted in the loss of wetlands, alteration of freshwater inflows, contamination of water, sediments and biota, and declines of fish and wildlife species (USGS).

When the California Gold Rush began in 1849, the open waters and bordering wetlands of the Bay covered 787 square miles. The Bay was shallow, two thirds of it less than 12 feet deep. The unfortunate result was that as the new State of California began to grow, the Bay began to shrink (See Figure 6). Shallow tidal areas were diked off from the open Bay to create salt ponds, farmlands, and duck hunting clubs. Municipalities used the Bay for garbage dumps. Siltation from hydraulic gold mining in the Sierra foothills washed into the Bay and filled wetlands. Numerous land reclamation operations were undertaken to create dry real estate where Bay waters once flowed. By the middle of the 20th century, the Bay's open waters had been reduced to 548 square miles and nearly a third of the Bay was gone (USGS, 1998).

The loss of 95% of the estuary's wetlands since 1850 has placed increased importance on the remaining 125 km2 of wetlands that continue to be threatened by development, erosion, pollution, and rising sea level (USGS).

Alteration of fresh water inflows

The flow of freshwater into the estuary has been greatly reduced by water diversions to support irrigated agriculture and growing urban population. Harbor and channel dredging have altered both the dredged and the disposal sites and changed water flow pattern salinity (Lionberger, 2009). The rapid urbanization of the Bay Area led to a lack of fresh water. The dams and reservoirs on the Tuolumne River in the Hetch Hetchy Valley of Yosemite National Park was built in 1931.The 136 miles aqueduct carried water to to meet the needs of San Francisco. The Pardee Reservoir on the Mokelumne River and the Mokelumne Aqueduct are also integral parts of the Bay Cities water system (Hornbeck, 1983).

Contamination of water

The basic pollution and water quality problems of the San Francisco Bay Area results from many circumstances such as depletion of stream flows and water storage projects which result in salt water incursion, the drainage of irrigation waters into the Bay, and municipal and industrial waste discharges (Davis, 1992). Since World War II the latter have increased under the pressure of population growth (Walsh, 1968). Each day, San Francisco Bay receives more than 800 million gallons of municipal wastewater containing 60 tons of nitrogen (USGS).

It is not clear which and to what extent particular human activities are responsible for specific unwanted ecosystem changes. Today, there are concerns about potential limitations to additional economic development because of demands on land and water supplies; increasing constraints on diverting water away from the

Delta because of concerns for endangered species; pressures to shift consumption of managed water from agricultural use to urban use; future land subsidence as a result of increasing dependence on ground water supplies in dry years; further loss of tidal wetlands to urban encroachment; and constraints on harbor improvements because of potential changes in salinity and contaminant levels as a result of dredging and spoils disposal (USGS). The urbanization of the San Francisco Bay Area had consequences at a local scale with the loss of 95% of the wetlands, but also had major land cover consequences at a larger scale with the construction of different dams to provide freshwater to the increasing population.

Conclusion

Like many large urban centers, the Bay Area will continue to grow over the foreseeable future. This area as many others will be confronted to two major issues; the constant population growth and the sea level rise.

Before 2030, the nine counties of the region are expected to add a total of 1,655,400 new residents, or 66,000 new residents per year. Santa Clara County (San Jose) is projected to continue to be the most populous county in the region and will also experience the greatest amount of growth, or nearly 23 percent over the next 25 years. San Francisco will see the least amount of growth of these high population counties, or almost 14 percent to 924,600 residents by 2030. Though not as populous as the above areas in the region, the fastest growing county in the Bay Area will be Solano County. By 2030, Solano will see a 27 percent increase in its population, to 581,800 residents (Focus).

The region faces the challenges of serving this growth with an efficient transportation system and balancing it with the conservation of open space and agricultural lands.

On the other hand, the San Francisco Bay Area will have to face the challenge of the sea level rise from global warming. This will have a profound impact in the Bay since, more than 200 square miles of low lying filled land borders the Bay (BCDC). Between 1900 and 2000, the level of the Bay increased by 7 inches. A research team has found that water levels in San Francisco Bay could rise an additional 5 inches to three feet by the end of this century (BCDC). This level of rise in the Bay could flood over 200 square miles of land. The value of the development threatened with inundation has been estimated by the Bay Conservation and Development Commission at over $100 billion worth of public and private development. For several decades, the challenge was to present San Francisco Bay to get smaller because of the continuous development of land filled on the Bay; But these last years, the challenge has shifted, and is now to prevent the Bay to expand on the developed areas surrounding the Bay. A plan developed in cooperation with all the actors of the Bay should be introduced to protect the Bay from being flooded. Some plans are already in place such as the San Francisco Bay Restoration Act that focuses mostly on the protection and restoration of wildlife and waterfowls ecosystems (Senate, 2010).

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Table of Contents

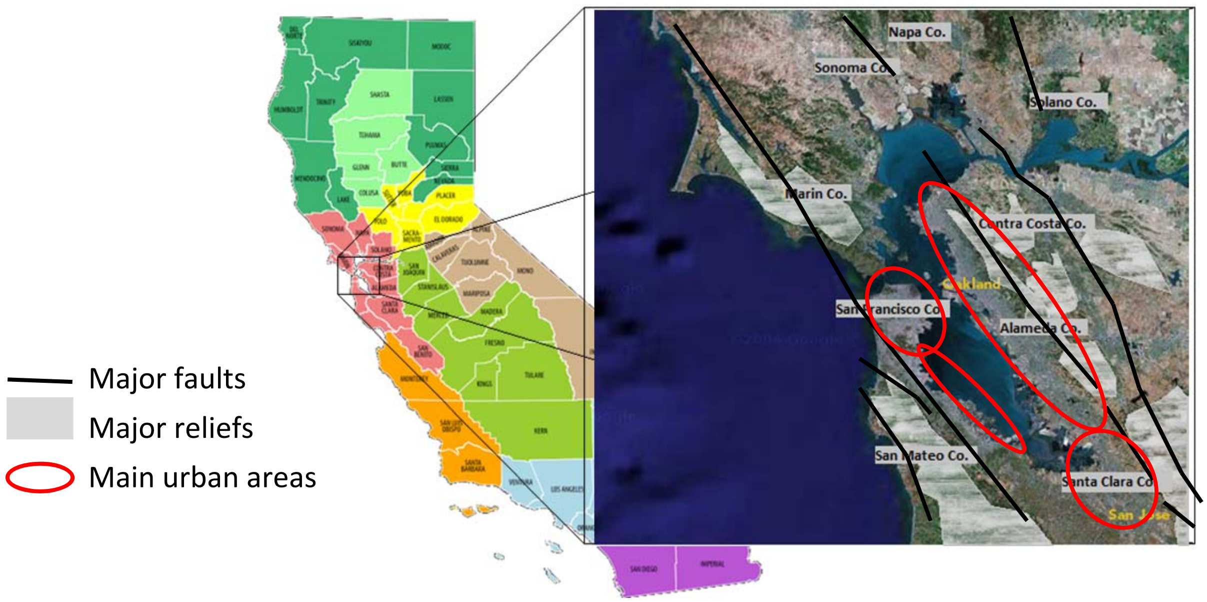

Figure 1: The San Francisco Bay area and its environmental settings

Source: USGS, 2002

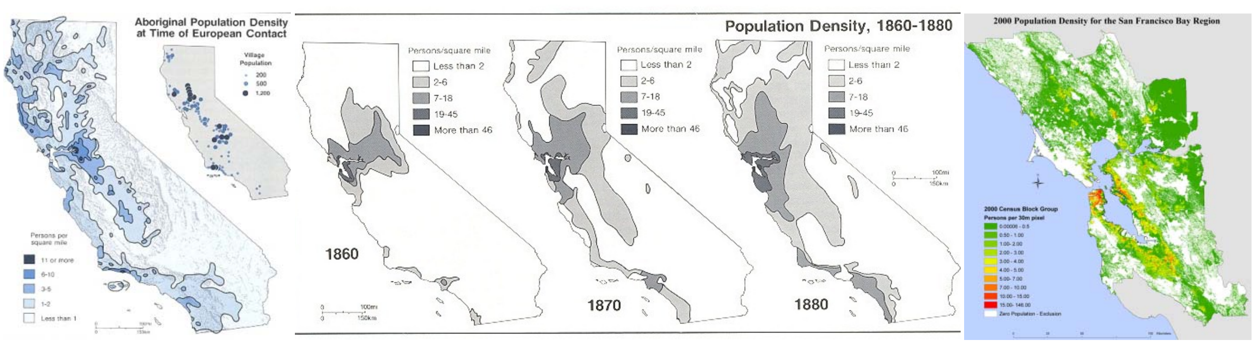

Figure 2: Evolution of the population density of the San Francisco Bay Area through time

Source: Hornbeck, 1983 and USGS

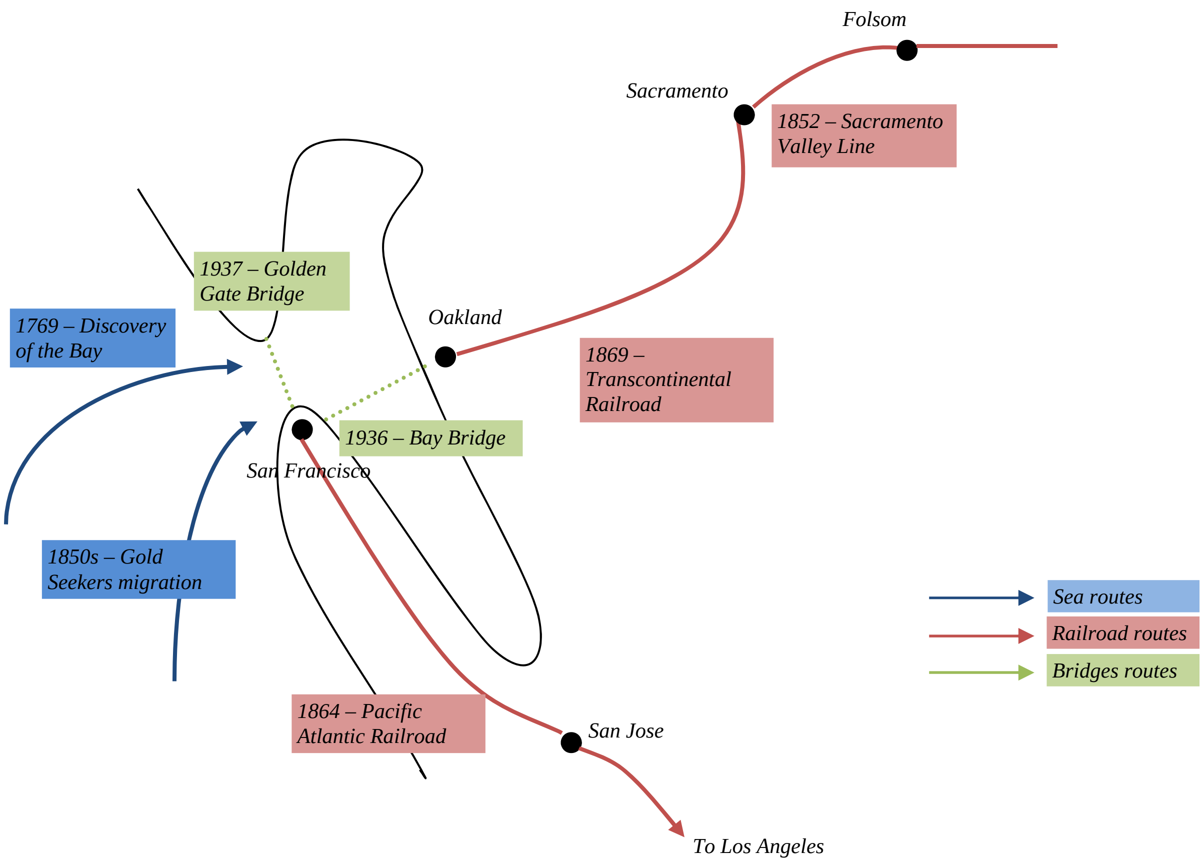

Figure 3: Main connections of San Francisco Bay Area to its surroundings through transportation means

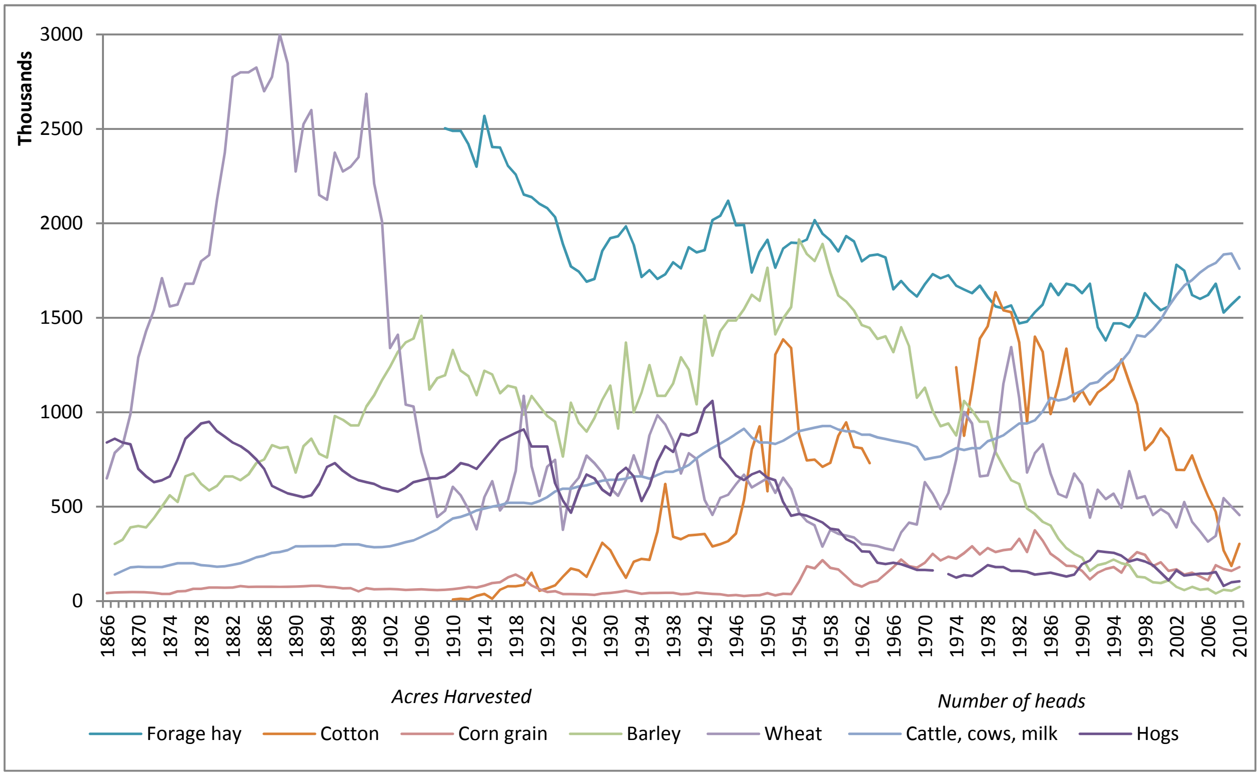

Figure 4: Evolution of the agricultural production in California between 1866 and 2010

Source: Census of Agriculture, California

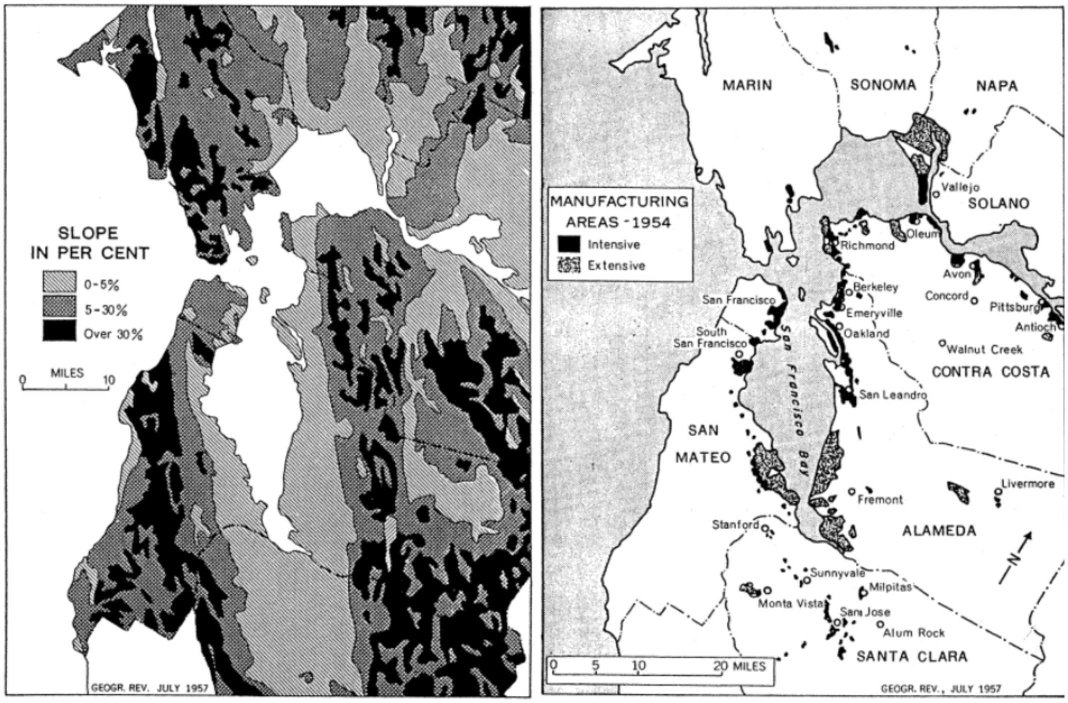

Figure 5: Example of natural constraints to the San Francisco Area Bay growth

Source: (Young, 1957)

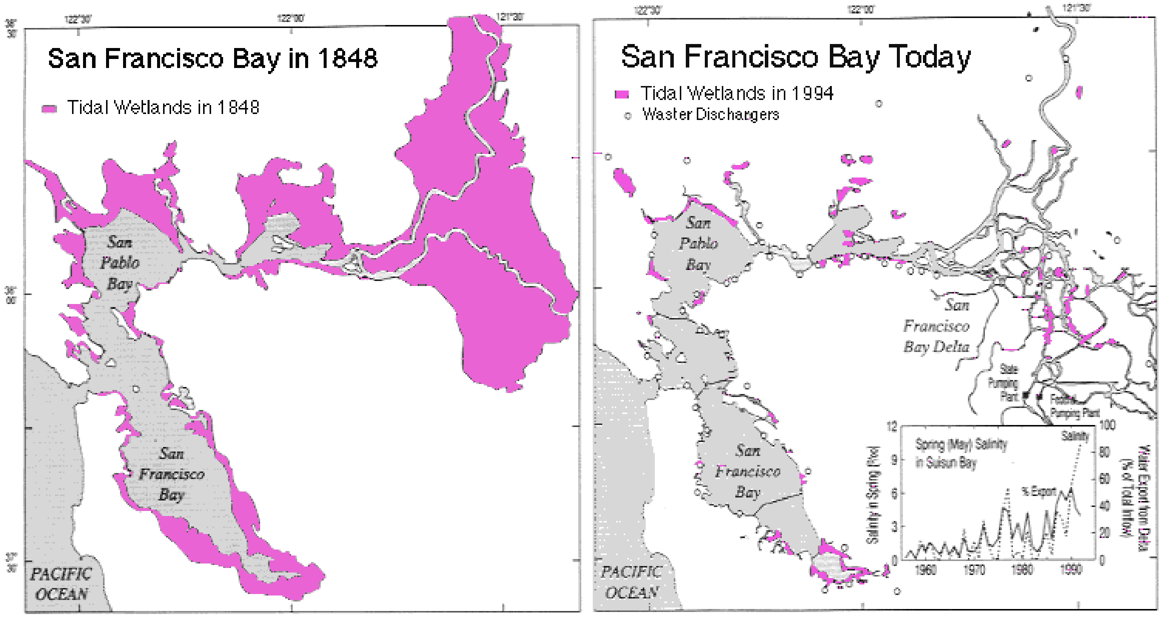

Figure 6: Consequence of the San Francisco Bay Area urbanization; Shrinkage of the Bay between the gold discovery time and today

Source: USGS

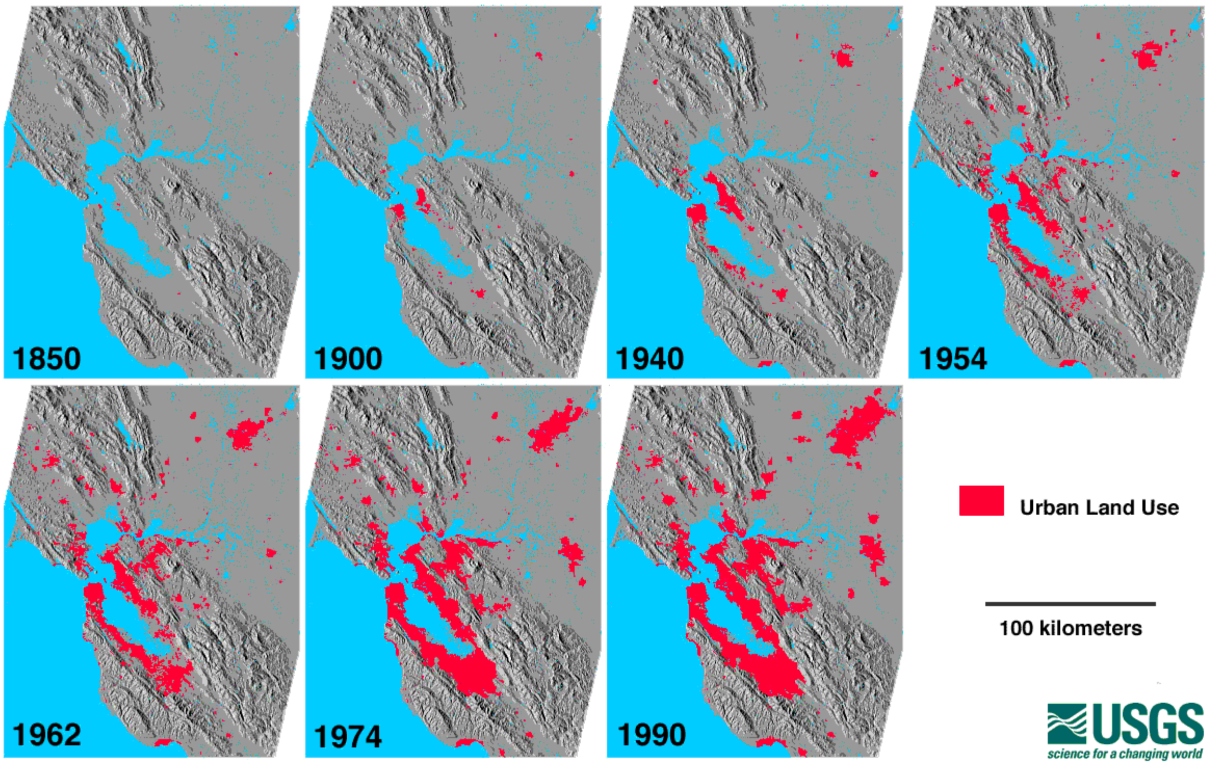

Figure 7: San Francisco Bay Urban Area development between 1850 and 1990

Source: USGS

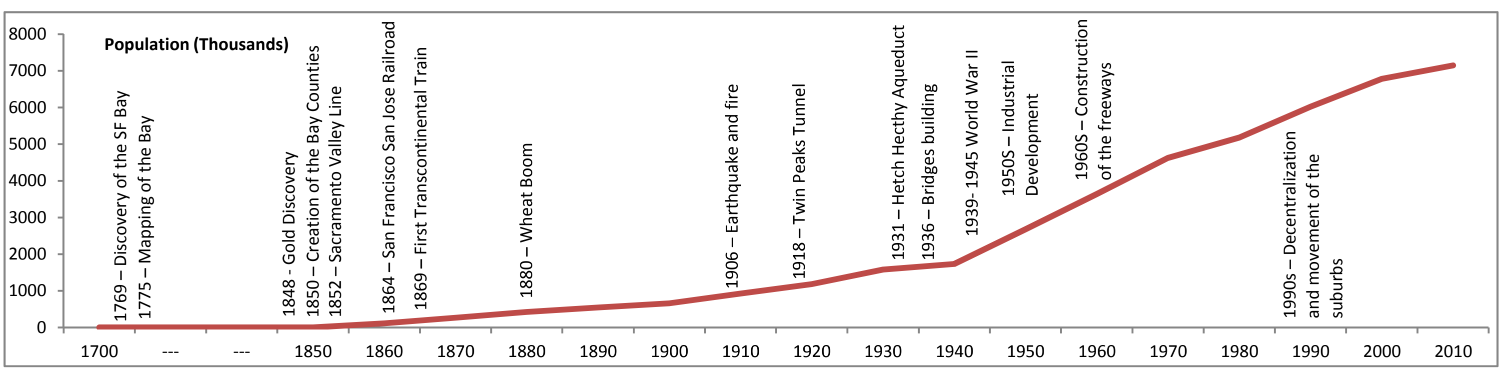

Figure 8: Timeline of the population evolution and the main events in the San Francisco Bay Area

Source: Census of Population

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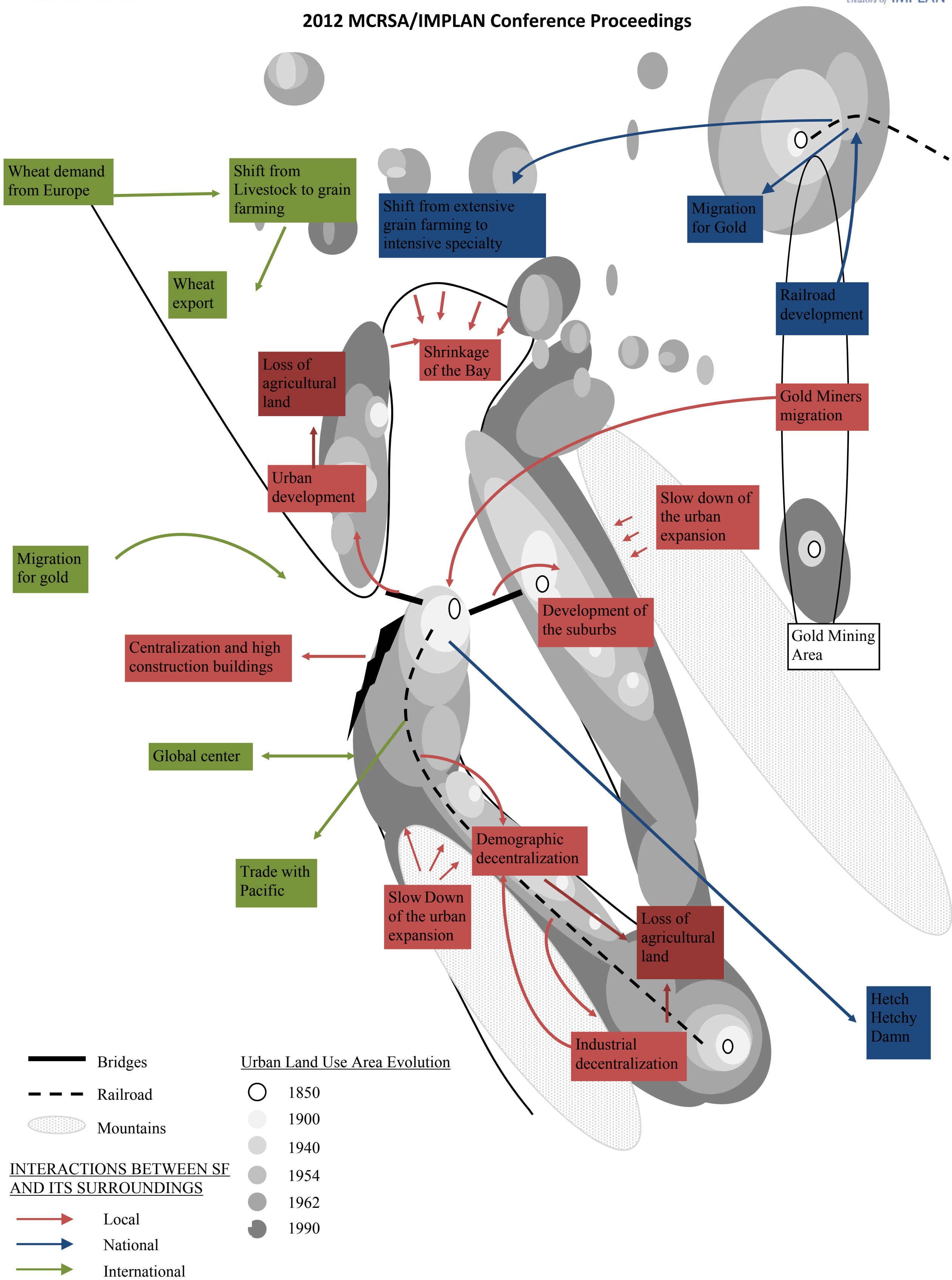

Figure 9: Author's representation of the level of interactions between the urbanization of San Francisco and the surrounding environment

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Is Irrigated Rice Cultivation Sustainable in Kurunegala District of Sri Lanka

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Abstract. With increasing population and development, demand for water increases rapidly, challenging the present water consumption pattern of the agricultural sector which uses more than 80 percent of total water supply of Sri Lanka. This compels policy makers in finding allocate efficiencies of irrigated rice water which consumes 70 percent of the total agricultural water. Thus, the objective of the study was to estimate the value of irrigated rice water and to discuss sustainability of irrigated rice cultivation in Kurunegala, one of the leading rice producing districts of Sri Lanka. Three methods were used to estimate irrigated water value, using a panel dataset for 22 years for both *Yala* and *Maha* seasons. Results indicate that estimated irrigated water value in *Yala* season, is even less than the operational and management cost of irrigation water and irrigated rice cultivation is not economically viable.

Keywords: Irrigation water, Economic valuation, Season, Rice cultivation

Introduction

Of all the sectors that use freshwater, agriculture claims 70 percent of global withdrawals from natural sources showing the lowest overall economic return (FAO[b], 2011; Gibbson, 1986; Huffaker and Whittlesey, 2000). This fact leads for water valuation for higher economic returns, under-growing water scarcities, increasing competition from industrial and domestic users, and alarm over the degradation of ecosystems (FAO[b], 2011). As the irrigation of agriculture crops accounts for the largest amount of water consumed in the world (Cosgrove and Rijsberman, 2000; Pimentel et al., 1997), sound valuations would make new irrigation projects and rehabilitation of existing irrigation facilities, economically efficient and socially viable. Further, it would help in proper management and sustainability of ground water too (Young, 1996). Beside, given the scarcity, water valuation is an economic tool that can be used to managing water demand, and sometimes in linking the gap between supply and demand of water.

In Sri Lanka, irrigated rice cultivation is the main agricultural crop that withdraws 60 to 70 percent of the allocated water for food production in the country (FAO[a], 2011). With increasing population and establishment of industries, demand for water in other sectors is increasing rapidly, challenging the present water allocation system for food production, especially rice cultivation. The issue becomes complex as rice is the staple food of Sri Lankans. Meanwhile, the predicted indicators of United Nations, International Water Management Institute, and Falkenmark show that Sri Lanka would face seasonal and temporal scarcities of water, especially in dry and intermediate zones; emphasizing the importance of efficient water management (Bandara and Weerahewa, 2003). Importantly, these two zones are the major domestic food suppliers i.e. rice. Beside, under prevailing settings of almost free irrigated water supply to rice farmers in Sri Lanka, water is used until its marginal productivity is driven to zero (Seagraves and Easter, 1983). Thus, valuing irrigated rice water would make sense of its efficiency and management which helps in reaching sustainable water allocation polices.

Concerning agricultural water valuation in Sri Lanka, Upasena and Abeygunawardena (1993) used productivity change method in valuing irrigation water in Devahuwa irrigation scheme. The study estimated that water value is SLRs750.00 (US$7.5) per acre per rotation and is higher than the operational and management cost of irrigation. Using liner programming model, Piyasena (2000) valued irrigated water for *Yala* season, SLRs[1]. 2030.00 (US$20) per acre-feet for a representative farm of many crops in Galenewa. Renvick (2001) estimated value of irrigation water for rice cultivation as SLRs. 6699.00 (US$66) per acre, using residual approach for Kirindi- Oya irrigation scheme for Maha season. Considering five districts of Sri Lanka, Bandara and Weerahewa (2003) estimated irrigated water value for rice cultivation as SLRs. 5728.00 (US$57) per acre per year. Sivarajah and Ahamad (2006) estimated economic value of irrigation water in crop farm (rice and chillies) in Gal-Oya irrigation scheme, using a liner programming approach and estimated the value as SLRs.6160.00 (US$61) per acre-foot.

This study attempts to estimate irrigation water value in rice cultivation for *Yala* and *Maha* seasons[2]in Kurunegala district and to discuss the results in the context of economic sustainability along with other potential indirect benefits of rice cultivation. Unlike previous studies, a panel dataset for 22 year period from 1986 to 2008 is used for the analysis.

The rest of the paper is organized into five sections. Section two provides a brief description of study area. Section three explains methodology and data sources. Section four describes empirical results and analysis. Section five presents conclusions.

Data and background of the study area

Kurunegala District spans part of the dry zone and the intermediate zone of Sri Lanka, which is 4,816 km² in area. The total population of Kurunegala is 1,569,000 (DOA, 2011) which is 8 percent of the total population of the country. The district is known mainly for its numerous coconut plantations, fruits farming, cash crops and rice cultivation. Of the total rice production of the country nearly 12 percent is cultivated in Kurunegala both in *Yala* and *Maha* seasons under irrigated and rainfed (DCS, 2011). The total labour force in the district is 51.1 percent and 30 percent is engaged in agriculture, mainly in rice cultivation. The total land area for rice cultivation in 2009 (*Yala* season) was 120,874 acres and the production was 7,878,000 bushels[3]. The values were 190,989 and 14,505,000 consecutively for the 2008/09 (*Maha* season). The poverty level of the district is significant; the head count index of poverty was 15 and majority of the poor are farmers (DCS, 2011).

Methodology

A number of methods and approaches are being followed in valuing water resource management (Young, 1996). This study uses three approaches to estimate irrigation water for rice cultivation in *Yala* and *Maha* seasons, with the intention of selecting the most reliable estima-

[1] Approximately 100 SLRs equals 1 US dollar

[2] Yala season is from April to September and Maha season is from October to January and rice is cultivated in both seasons

[3] 1 Bushel is approximately 21 kgs

tion of irrigated water, which could use for a better discussion and conclusion.

With and Without Approach

In this approach the difference between the net returns of production per unit area in irrigated rice cultivation and non-irrigated (rainfed) rice cultivation is considered as the value of irrigation water under the similar conditions of all other affected factors.

Residual Approach

This method is one of the most frequently used approaches in valuing irrigated water. The value of water is defined as the difference of total crop value and non-water input costs like agro chemicals, machinery, labour etc.

Derivation of water value (Residual value) is based on two postulates, i.e. profit maximizing producers are assumed to productive inputs up until the point that value marginal products are equal to opportunity costs of the inputs and condition requires that the total value of product can be divided into shares, so that each resource is paid according to its marginal productivity and total value of product is there by completely exhausted.

Consider an agricultural production process that has a Y production and factors of inputs of capital (K), Labor (L), other inputs(R), and irrigated water (W). The production function is:

$$Y = f(K, L, R, W) \tag{1}$$

If competitive market mechanism is prevailed, prices can be treated as constants. Then function is as:

$$TVP_Y = (VMP_K * Q_K) + (VMP_L * Q_L) + (VMP_R * Q_R) + (VMP_W * Q_W) \tag{2}$$

Where TVP_Y represents total value of product Y, VMP represents value marginal product of input i, and Q is the quantity of input i. By substituting and rearranging based on the first postulate:

$$P_W * Q_W = TVP_Y - ((P_K * Q_K) + (P_L * Q_L) + (P_R * Q_R)) \tag{3}$$

Where P_w is unit value of water, Pi is the unit value of other inputs.

On the assumption that all variables are known except P_w, that expression can be solved for that to unknown to impute the value (shadow price) of the residual claimant (water) as follows:

$$P_W = \{TVP_Y - ((P_K * Q_K) + (P_L * Q_L) + (P_R * Q_R))\} / Q_W \tag{4}$$

Crop-water Production Function Approach

If the objective function of a profit maximizing firm is as:

$$Max\pi = P*Y - W_i X_i \qquad s.t. Y = Y(X_i, Z) \tag{5}$$

where, P and W are the prices of output and inputs respectively, X_j is the variable inputs and Z denotes the irrigated water, the first derivation with respect to irrigation water provides the value of water or the shadow price of water:

$$\delta\pi / \delta Z = P * MP_Z \tag{6}$$

MP_z is the marginal product of output with respect to irrigation water. The equation 6 can be quantified if parameters for production and output price are available. Thus, a linear version of a production function is estimated in valuing irrigated water in rice cultivation.

Data and Study Area

Data for the study was mainly collected from the cost of cultivation reports (1986-2008) of the Department of Agriculture, Sri Lanka. Data on rice production amounts, labour, machinery, fertilizer and other fixed costs per acre were gathered from those reports. Department of Labour, and Department of Census and Statistics (DCS, 2011) were the other major sources of information. A panel dataset of rice cultivation for 22 years for both the seasons of *Yala* and *Maha* were used for the analysis. The statistical package of STATA 9.1 was used as the analytical tool.

Result and Discussion

With and Without Approach

When all the factors such as soil type, weather, seed type, input costs are similar the difference in net returns between irrigated and non-irrigated, can be attributed as the irrigated water value of rice cultivation. As the amount of rainfall differs with seasons of *Yala* and *Maha*, value of irrigated water also gets changed in the approach. Results indicate that irrigated water values of each season are inconsistent and vary significantly (Table 1). However in average basis, irrigated water value could be attributed as SLRs. 3223.00 per acre (US$33) in *Maha* season and SLRs. 2952.00 per acre (US$30) in *Yala* season.

The difference between the output value and the values of inputs with managerial cost was attributed as the irrigated water value of paddy cultivation. The managerial cost was considered as the 5 percent of the value of production, following Young (1996) and Renwick (2001). Results show (Table 2) a significant variations in values of irrrigated water in each season same as with and without approach. However, the average water values for *Maha* and *Yala* seasons are SLRs. 2437.00 (US$24) and SLRs. 2391.00 (US$24) respectively which are less in value compared to with and without approach.

Table 1 . Value of irrigated water per acre for Maha and Yala seasons in SLRs

Year	Net returns		Water value
	Irrigated	Rainfed	
Maha season			
81/82	5041.20	4148.40	893.70
85/86	10294.40	9351.50	942.80
91/92	12559.80	6656.00	5903.90
95/96	15369.50	10329.60	5040.00
2001/02	24187.50	23412.50	775.00
2004/05	21450.00	13037.50	8412.50
Yala season			
1981	4116.50	3733.20	383.30
1985	6897.10	4501.10	2396.00
1990	12657.50	8926.10	3731.40
1995	13847.80	9168.60	4679.20
2004	26850.00	12762.50	14087.50

Residual Approach

Table 2. Value of irrigated water per acre for Maha andYala seasons in SLRs

Year	Total revenue	Total variable cost	Water value
Maha season			
84/85	5526.40	2778.40	2471.68
90/91	7507.90	6148.70	983.82
95/96	13438.90	10058.30	2708.65
99/00	19413.10	11761.20	6681.24
04/05	21450.00	21521.90	-1144.50
Yala season			
1981	4116.50	2500.50	1410.17
1985	6897.10	3392.30	3159.94
1990	12657.50	6479.50	5545.12
1995	13847.80	10766.30	2389.11
2000	19960.50	16729.90	2232.47
2004	26850.00	21029.00	4478.50

Crop-water Production Function Approach

In this approach labour, inputs costs (fertilizer, seed, pesticide, and weedicide), capital cost and water were considered as the independent variables of crop yield. Water was used as a dummy variable i.e. dummy equals to one for irrigated water and zero for otherwise (rainfed). So the coefficient of the dummy variable shows the productivity difference of water availability under the assumption of all other factors like sunlight, temperature, soil conditions and rainfall are similar.

Table3. Descriptive statistics for *Maha* and *Yala* seasons

		Maha Season		*Yala Season*	
Variable	**Units**	**Mean value**	**Standard deviation**	**Mean value**	**Standard deviation**
Yield	Kg/acre	1,506.82	258.37	1,389.41	357.54
Labour	Man days/acre	52.22	13.04	51.11	11.55
Input Cost	SLRs/acre	1,888.50	1,216.28	1,876.76	1,351.15
Capital Cost	SLRs/acre	1,472.10	1,023.19	1,301.69	1,066.82

Table 4. Econometric results for *Maha* and *Yala* seasons

Independent variable	*Maha Season*			*Yala season*		
	Coefficient	**Std error**	**P value**	**Coefficient**	**Std error**	**P value**
Intercept	1,039.621*	315.79	0.003	527.921***	304.62	0.091
Labour	4.471	4.65	0.345	10.352**	5.10	0.052
Input cost	-0.002	0.06	0.840	-0.001	0.06	0.891
Capital cost	0.006	0.08	0.438	0.183**	0.08	0.032
Water (dummy)	321.591*	71.28	0.000	190.891***	106.77	0.081
	R^2 = 0.48 Adj.R^2 =0.41 F= 6.89 DW =1.98 N = 35			*R^2 = 0.38 Adj.R^2 =0.31 F= 4.52 DW =2.32 N = 34*		

*(Dependent Variable: Paddy Yield, Kg/acre) *, **, *** significant at 1%, 5%, and 10% level*

Table 3 and 4 show descriptive statistics and econometric estimation for both seasons. Considering *Maha* season, model explains 48 percent of the variation and dummy variable for water and intercept term are significant at 5 percent level (Table 4). The coefficient for water dummy indicates that productivity under irrigated water is 321.59 higher by kg/acre. When price of rice is considered as SLRs. 13.00 (US$0.13) per kg (which is the average buying value of rice by government in 2008), irrigated water value of rice cultivation can be estimated as SLRs. 4180.00 (US$42) per acre for *Maha* season.

Considering *Yala* season the model explains 38 percent of the variation. The independent variables of labour, capital cost and dummy for water are statistically significant under 5 percent and 10 percent level. The coefficient of water dummy shows that 190.89 kg per acre can be produced more under irrigated water. Taking price of rice as SLRs 13.00 (US$0.13), irrigated water value can be estimated as SLRs. 2481.00 (US$25) per acre for Yala season (Table 4).

Results indicate different values for the three different methods. However, estimations of production function approach are used for the discussion as its marginal increment of yield with changing water availability provides a sound and reliable approximation compared to other two approaches. According to production function approach, irrigation water value is SLRs. 4180 (US$42) for *Maha* seasona and SLRs. 2481.00 (US$25) for *Yala* season, drastically low values. Based on the cost estimation of Shilpi (1996), it does not cover even the operational and manintanance cost of irrigation, especially in *Yala* season. Thus, if operation and maintenance cost of irrigation water is charged from rice farmers there won't be any direct economic gains for rice cultivation in Kurunegala and rice cultivation seems to be unsustainable. However, currently irrigation water is given in free of charge in Sri Lanka, may be in the context of farmers poor economic situation, inadequate employment alternatives, and importance of rice as the staple food. However, according to the analysis, prevailing irrigated rice cultivation demands a drastic re-vitalization of rice sector and water management.

Some argue that irrigation water for rice benefits in many ways than direct economic gains of rice cultivation, i.e. multifunctional benefits. Valuation towards multifunctionality of rice cultivation considering the numerous other benefits associated with rice cultivation are not uncommon, especially in Asia and Europe, where important potential benefits of agriculture, in addition to the direct economic gains, are recognized. Research outcomes of such valuations are commonly found in rice producing countries like Japan, Myanmar, Korea, Thailand, China, Vietnam, Taiwan, Philippine, and Indonesia (Huang et al., 2006; Kim et al., 2006; Matsuno et al., 2006). In certain countries policy implementations based on the approach are being practiced (Groenfeldt, 2005). Beside, researches reveal that rice lands serve as close as the wetlands (Lambert, 2012) and their service is very much relevant to the wetlands

In Sri Lankan context a few such studies are reported in dry and intermediate zones. Renwick (2001) found in Kirindi-Oya irrigation reservoir, that the reservoir based fishing provides a source of nutrition to rural people and a self-reliant employment. A study of JBICI & IWMI (2002), explained that irrigation water for rice absorb 'shocks' of droughts in dry zone of Sri Lanka, which prevents chronic poverty in dry zone. Seneviratne (2004) showed that water quality is considerably higher in shallow dug wells compared to deep tube wells in the irrigated areas in WeliOya irrigation. A study carried out in MauAra, a tributary of Walawe River; diversion project area revealed positive impacts of irrigation development on ground water recharge. The study showed that groundwater levels deplete when irrigation is reduced, especially in dry months (Panabokke et al., 2007).

Considering Kurunegala district, though such studies are not reported still, potentials of such gains are higher with the available irrigation schemes throughout the district. According to the Irrigation Department of Sri Lanka (2012), there are 8 major irrigation schemes in the district with a command area of 27,355 acres of rice lands. The district has many other minor irrigation schemes with a potential command area of 95,000 acres (Wijesooriya , 1982). According to Panabokke (2000), 2481tanks of ancient irrigation schemes are available in the district which mostly irrigate rice cultivation. Inland fisheries are based on those irrigation schemes are significantly available where 3,641 active fishers were in 2009 (DCS, 2011). Majority of the households use well water for drinking purposes, and a considerable amount use irrigated water for other domestic purposes (DCS, 2011).

Thus, multifunctional aspects indicate that Kurunegala district has excluded other benefits like fishing, ground water recharging, 'shocks' absorb of drought, aesthetic beauty and all other ecological gains associated with irrigated rice cultivation which are prominent in dry and intermediate zones. And including those values would make higher return for irrigated water.

Conclusions

The study reveals that direct economic returns of irrigated rice cultivation for both seasons are less in Kurunegala district. The return is significantly low in *Yala* season and less than even the operational and maintenance cost of irrigation. If government charges the operational and maintenance cost of irrigation water rice cultivation is not be viable, and sustainable. With potential inclusion of other gains of irrigated water, economic returns of rice cultivation may be increased. However, further research and estimations on these indirect benefits are essential to decide that.

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An Examination of Short-Run and Long-Run Factors Affecting Regional Income Inequality in the United States

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Abstract. This paper examines theoretical and empirical explanations for recently observed increases in regional income variation in the United States. Evidence indicates that regional income variation, after decades of decline, began increasing in the United States in the mid-1970s and has continued into the early 2000s. Alternative theories of unbalanced regional growth are examined to differentiate short-run shocks from long-run development trends. Ordinary least squares regression techniques are used to discern the degree to which increasing regional income variation is the result of short-run shocks or a long-run trend. Results indicate that national short-run shocks can affect regional income inequality, but they do not supplant increases attributable to long-run development.

Introduction

Unbalanced regional growth and its implications for the inequality of per capita regional income has been theoretically and empirically investigated by numerous authors over the past several decades, including Chenery [11], Eckaus [13], Hughes [18], Lasuen [26], Baer [7], Williamson [38], Dixon and Thirlwall [12], Smith [33, 34], Lande and Gordon [24), and Persky and Tam [30]. A unifying theme of this body of literature has been examination of the convergence of regional incomes and the decline in regional per capita income inequality, a phenomenon generally expected for advanced, industrialized countries. Regional income convergence is the anticipated phenomenon due to the widely accepted implications of the neoclassical theory of factor market equilibrium adjustments. Convergence in this context is a result of regional factor markets adjusting to massive disequilibrating shocks associated with the industrial revolution.

Early empirical studies of regional income differentials have generally supported expectations of convergence. Williamson [38] found evidence of regional convergence for the United States and several other highly developed countries. In a classic study of regional growth, Borts [9] also found support for convergence in the United States. Moreover, the Bureau of Economic Analysis (BEA) regularly provides evidence of per capita income convergence among states, as exemplified by Friedenberg [14] and Johnson and Friedenberg [19].

Although regional income convergence is theoretically expected and was empirically identified in earlier studies, more recent analysis provides evidence of diverging regional incomes and increasing regional per capita income inequality in the United States since the mid-1970s, as discussed by Amos [1]. Because divergence is contrary to conventional expectations and is a relatively recent occurrence, two possibilities are implied. The first is that the observed divergence is a short-run aberration from the expected long-run convergence trend conventionally associated with development. The second is that the divergence is a reversal in the long-run, historical trend. While the case of a short-run aberration is consistent with conventional explanations if exogenous disequilibrating shocks have occurred, the case of a long-run trend reversal indicates that our current understanding of the process of unbalanced regional growth is incomplete and that existing theoretical explanations are lacking.

In this light, the primary objective of this analysis is to investigate the underlying cause or causes of increasing regional income inequality observed in the United States in recent years. This is accomplished first by examining alternative theoretical explanations underlying unbalanced regional growth to identify potential causal variables, and second by testing the identified variables for the United States economy using standard statistical regression techniques.

Regional Inequality in the United States

An empirical analysis of regional income inequality in the United States by Amos [1] indicates that regional inequality, after a period of decline, began increasing in the mid-1970s. This conclusion is based on time-series regression analysis of *intrastate* regional income inequality (the variation of per capita income in counties relative to the respective state) for all 50 states between 1969 and 1983 and cross-section regression analysis of Census data for 1950, 1960, 1970, and 1980. Results indicate that *intrastate* income inequality (inequality among counties within a state) exhibited signs of increase for 37 of the 50 states. Moreover, 18 of the states began increasing between 1975 and 1976, with the majority of the states showing signs of increasing regional inequality during the 1970s.

Cross-section analysis for the past four Census years indicates that states with higher per capita incomes tend to follow a pattern of declining, then increasing regional inequality. Moreover, this pattern has changed from one Census year to the next, with earlier Census years containing more states in the declining portion and latter years with a relatively larger number of states in the increasing portion. The 1980 Census depicts a situation in which a large number of states have reached their minimum regional inequality values. This is consistent with the time-series analysis indicating the majority of the states exhibited increasing inequality during the 1970s.

Figure 1 presents graphical evidence of *interstate* regional inequality for the United States from 1929-2011 (the variation of per capita income in each state relative to the nation). Using a population-weighted standard deviation measure of the variation of state per capita income relative to the national average employed by Williamson [38, p. 11], this figure indicates that *interstate* income inequality generally converged between 1932 and 1978, and while there are signs of divergence from 1978 to 1988 and the trend from 1994 to 2011 is in a slight divergence, the overall pattern from 1973 to 2011 is relatively flat.

More recent analysis of regional income inequality by Amos [6] from 1969 to 2006 indicates a pattern of the *intrastate* divergence across a majority of the 50 states in the U.S. with no evidence of convergence that characterized the period prior to the mid-1970s. In this latter analysis the measure of *intrastate* regional income inequality is the population-weighted standard deviation measure of the variation of county per capita income relative to the respective state average compared to the *interstate* income inequality exhibited in Figure 1.

This poses the questions addressed by this paper. Was there a long-run transition from convergence to divergence in the later 1970s? If so, was this long-run divergence trend circumvented temporarily due to short-run shocks? Or is any apparent divergence detected in an aberration brought on by short-run shocks to what would otherwise be a pattern of convergence?

Theoretical Explanations of Unbalanced Regional Growth

Four basic theories have been conventionally applied to the study of unbalanced regional growth – neoclassical, export base, growth pole, and cumulative causation. Each theory provides implications for potential causes of increasing regional income inequality.

Neoclassical

The neoclassical regional growth theory, building on the work of Solow [35], employs the standard assumptions of competitive markets, factor mobility, and utility/profit maximization to explain convergence observed among regional incomes. As extensively discussed by Borts [9], Borts and Stein [10], Vinod [37], Smith [33, 34] and Lande and Gordon [24], unbalanced regional growth is explained by the neoclassical theory through a process of exogenous disequilibrating shocks followed by regional product and factor market equilibrium adjustments. In the context of regional income differentials, exogenous shocks or predetermined historical situations distort the interregional factor price equilibria and create regional income differentials.

Based on the standard neoclassical assumptions as presented by Borts [9, p. 320], ". . . (1) the total supply of labor to all regions taken together is fixed; (2) a single homogenous output is produced in each region; (3) there are zero transport costs between regions so that the price of output is regionally uniform; (4) the same production function exists in each region, being homogenous of degree one in inputs labor and capital; (5) there are zero costs of converting output into capital goods," convergence and equalization of factor returns is essentially guaranteed. Labor and capital mobility between competitive factor markets generates the adjustment needed to re-achieve equilibrium conditions. In particular, labor migrates from low-wage to high-wage regions and capital moves in the opposite direction, both leading to the equalization of factor returns and thus convergence of regional incomes. Barriers to factor mobility extend the equalization and convergence process over several decades, generating the pattern of decreasing regional inequality observed for most of this century.

As such, *increasing* regional income inequality in the neoclassical theory is attributable to exogenous shocks. Items most often cited as disequilibrating shocks are technological innovations, unequal factor resource endowments, new resource discoveries, exogenous changes in demand for regional exports, wars, and changes in government policies. In reference to increasing regional inequality noted during the 1970s, potential candidates for exogenous, disequilibrating shocks consistent with the neoclassical theory include: (1) rapid increases in petroleum prices brought about by the Organization of Petroleum Exporting Countries (OPEC), (2) changes in macroeconomic fiscal and monetary stabilization policies, and (3) changes in international trading patterns between the United States and other countries.

A characteristic of the 1970s most relevant to this analysis of regional inequality is the "unusual" period of stagflation, with high rates of both inflation and unemployment occurring simultaneously, brought about in part by a tripling of petroleum prices by OPEC in 1973 and again in 1978. This action contributed to changing patterns of international trade as the high price of imported petroleum shocked the United States' balanced of trade. Moreover, problems of inflation and stagflation were likely compounded by the federal government's monetary and fiscal policies. The incidence of increasing regional inequality, contrary to historical trends, and the abnormal nature of macroeconomic activity could be mere coincidence, or it could be reflective of a causal relationship between the two.

Sharp increases in petroleum prices and resulting changes in international trading patterns could have stimulated growth and economic activity in petroleum production regions while inhibiting it in petroleum consumption regions, leading to disequalization of factor payments and greater regional inequality. Moreover, macroeconomic stabilization policies, which historically have differential regional impacts, also could have accentuated regional inequality. The neoclassical theory of regional growth thus implies three potential categories of explanatory variables for this analysis of regional inequality – resource prices, especially petroleum; macroeconomic stabilization policies, including changes in federal government expenditures, taxes, and the money supply; and patterns of international trade, especially petroleum imports and exports.

Export Base

Although the neoclassical theory allows for exogenous shocks from changes in demand for a region's export to generate disequilibrium, the export base theory incorporates this causal factor as a central component. North [28] was one of the first to explicitly argue that export base activity plays a critical role in regional growth and development. While export base as discussed by Richardson [31] has often been used as a simple model used to evaluate regional impacts attributable to changing economic activity, Hartman and Seckler [16] and North [28], argue that exports of regional production are the primary stimulatory cause of regional growth.

The export base theory is built on the assumptions that (1) regions have comparative advantages in the production of specific goods due to natural resource endowments, and thus form an export base as they specialize in these goods, and (2) a significant amount of all economic activity in a region is dependent upon export base production through residentiary or ancillary output needed by the export base activity. Working from these assumptions, the export base theory indicates that the growth of a region is dependent on growth of the export base sector. Additional production in the export base sector generates a multiplicative impact on production in ancillary and residentiary activities in the region. Growth in the export base sector is dependent on an exogenously determined demand for the region's export activity. Unbalanced regional growth and regional inequality are consequently determined by differentials in exogenously determined demand for regional exports, including existing or newly discovered export products.

The most significant implications of the export base theory for analysis of increasing regional inequality in the 1970s are exogenous changes in national and international demands for regionally produced goods. This includes, but is not limited to, changes in the demands for energy, automobiles, computers, and agricultural goods by international and national sources. Demand for energy produced by the southwestern region was clearly affected by the factors underlying the energy crisis discussed earlier. Demand for regionally produced automobiles was changed by energy prices and by the introduction of competition from foreign markets. Innovations in computer technology generated demands for previously untapped resources in some regions. And agricultural production in the midwest was affected by international production shortages. Demands for these and other goods have differential regional impacts and could potentially explain unbalanced growth and increasing regional inequality occurring in the 1970s.

The export base theory implies several explanatory variables in a general category of national and international demand patterns. This would include changes in imports and exports between the United States and other countries, especially petroleum, automobiles, and agricultural goods; changes in the distribution of national production among economic sectors, including production by private sectors and the government; and the introduction of new product types, most notably those based on innovations in computer technology.

There is an obvious degree of overlap between potential causal factors implied by the neoclassical and export base theories. This should be expected since both attribute unbalanced regional growth to exogenous occurrences. The primary difference between these two theories is that the export base theory explains how the disequilibrating exogenous change is implemented throughout the entire regional economy, and the neoclassical theory explains how regions adjust back to equilibrium once the exogenous change has been fully implemented.

Growth Pole

The third basic theory that can be used to explain unbalanced regional growth, termed growth pole theory, is based on a body of literature developed by Perroux [29], Hirschman [17], Hansen [15], and Lasuen [26]. Growth pole theory builds on the proposition, as stated by Perroux [29, p. 94], that ". . . growth does not appear everywhere at the same time; it becomes manifest at points or poles, with variable intensity . . .." This theory assumes that growth is stimulated by activity in key sectors in the economy, which through the operation of "motor" industries act to transmit growth to the rest of the economy.

In Perroux's original analysis, a growth pole is formed as a method of diffusing technological innovations throughout the economy. The motor industry lying at the heart of a growth pole acts as the driving force for growth through both economic and spatial interdependencies. Economic linkages between inputs and outputs, regardless of spatial linkages, generate the basic concept of a growth pole. However, if spatial linkages are also involved, then the concept of a growth center is generated, which is tantamount to a major urban area.

The mechanism underlying the transmission of growth involves what Hirschman [17] terms "polarization" and "trickling down" effects. The polarization effect occurs as a growth pole/ center grows in a cumulatively reinforcing manner at the expense of other regions or sectors of the economy during early stages of the growth process. The polarization effect occurs process because the growth pole/center is exploiting increasing returns to scale and/or agglomeration economies. The trickling down effect subsequently takes over as the pole/center stimulates growth throughout the economy. This effect is made possible through improvements in spatial and economic linkages, most notably transportation systems, during the growth process. The trickling down effect eventually dominates the polarization effect when increasing returns to scale and agglomeration economies at the pole have been exhausted and transportation systems have improved significantly.

The growth pole process has obvious implications for unbalanced regional growth and regional inequality. Increasing regional inequality occurs during the polarization process as the pole/center outpaces growth in the rest of the economy. However, regional inequality decreases with the trickling down effect as the rest of the economy catches up to the growth pole. The period of convergence observed until the mid-1970s in the United States would thus be explained by the growth pole theory as operation of the trickling down effect following an extended period of polarization during the early stages of the country's growth.

An explanation of increasing regional inequality beginning in the 1970s can be obtained through the polarization effect. This theory indicates increasing regional inequality would occur if a new growth pole is formed or an existing pole is rejuvenated. Possible occurrences in the 1970s that might correspond with this causal explanation are (1) the growth or rebirth of major urban areas or growth centers; (2) an increase in suburbanization, which could be thought of as the rise of "secondary" growth centers around the primary growth centers; and (3) the formation of new growth poles with motor industries generated by major technological innovations, such as computer technology and the silicon chip. While the growth pole theory, like the neoclassical and export base theories, highlights the potential causal role of technological innovation, this theory also indicates a potential role for the spatial dimension underlying the growth of urban and suburban areas could explain the phenomenon of increasing regional inequality.

Cumulative Causation

A fourth theory of regional growth, the cumulative causation theory, has many similarities to the growth pole theory. The cumulative causation theory, contained in literature discussed by Myrdal [27], Kaldor [29, 21], and Dixon and Thirlwall [12], is based on the proposition that regional growth tends to be cumulatively reinforcing. The central assumptions underlying this theory are: (1) the growth rate of productivity is directly related to the growth rate of output, (2) efficiency wages (money wages divided by an index of productivity) are inversely related to the growth rate of productivity, and (3) the growth rate of output is inversely related to efficiency wages.

These assumptions imply that growth triggered by an exogenous stimulus will continue in a cumulatively reinforcing manner. In this theory, increases in output lead to increases in productivity, the higher productivity decreases the efficiency wage, the lower efficiency wage then leads to further increases in output, which starts the sequence over again. The triggering mechanisms included exogenous changes in export demand or resource endowments.

The cumulative causation theory includes two effects that are essentially identical to the polarization and trickling down effect of the growth pole theory, termed "backwash" and "spread" effects by Myrdal [27]. The backwash (polarization) effect underlies the cumulative nature of growth causing one region (an urban area) to grow at the expense of other regions (the periphery of the urban area). The spread (trickling down) effect can theoretically counter the cumulative nature of the backwash effect, but Myrdal [27] and Dixon and Thirwall [12] argue that it is generally not strong enough for this task. This is in contrast to the growth pole theory, which indicates the trickling down effect will overcome the polarization effect as growth progress.

As such, unbalanced regional growth and regional inequality is affected in the cumulative causation theory by differential changes in export demand or changes in resource endowments, essentially the same as the export base theory. Exogenous stimulation leads to either cumulatively reinforcing growth, if the trigger mechanisms are upward, or decline, if they are downward. This implies regional inequality occurs because (1) exogenous shocks are positive for one region and negative for the other; (2) exogenous shocks are greater for one region than for another; or (3) for a given exogenous stimulation, structural differences generate different growth rates between regions.

Implications by the cumulative causation theory for explanatory causal variables in this analysis are covered by previous discussions of the export base and neoclassical theories. Regional inequality during the 1970s would be attributable to the same types of exogenous factors relating to changes in export demand and resource endowments, including factors related to the energy crisis and stagflation and technological innovations.

Growth Pole Cycle Theory

While each of these theories provides a degree of insight into the prospects of diverging regional income, an alternative, more comprehensive theory offers further theoretical direction. The growth pole cycle theory developed in Amos [4, 5] combines the spatial fundamentals of Perroux's [29] growth pole analysis noted earlier with the temporal aspects of long waves or long cycles original discussed by Kondratieff [22, 23] and further examined by Schumpeter [32], Booth [8], and van Dujin [36]. The growth pole cycle theory implies a endogenous process in which an economy traverses a 50-year "polarization phase" followed by a 50-year "spread phase." Similar to the growth pole theory, this process involves a fundamental spatial dimension, however, with the added temporal dimension of the long cycle process.

During the 50-year polarization phase regional incomes diverge as economic activity, productive resources, and wealth are geographically concentrated. During the 50-year spread phase regional incomes converge as economic activity spreads outward from the concentrated pole to the periphery.

The temporal dimension of this theory suggests that the Great Depression of the 1930s was transition between the diverging polarization phase and the subsequent converging spread phrase. The spread phase, and convergence, then continued until the late 1970s or early 1980s, which marked the transition to a new diverging polarization phase.

The objective of this analysis is to investigate the long-run trend of regional income divergence or convergence. Although empirical evidence suggests that convergence gave way to divergence by 1980, data are not unambiguous. As with any long-run trend, short-run effects could be distorting the pattern. Alternatively the appearance of a long-run trend of divergence might be nothing more than one or more short-run disruptions.

Methodology

To test for the potential causes of increasing regional income inequality, ordinary least squares regression techniques are used on pooled cross-section, time-series data encompassing regional income inequality estimates for all 50 states from 1969 to 2009. Based on previous analysis [1, 6] identifying the importance of real per capita state income and the number of counties in each state as explanatory variables, the following equation is estimated.

$$V_{it} = \alpha + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 CN_i + \beta_4 X_{it} + \varepsilon_{it} \quad (1)$$

where: V_{it} = a measure of regional income inequality for state i and year t, Y_{it} = state per capita real income in state i and year t, CN_i = the number of counties in state i, X_{it} = one or more of the potential explanatory variables discussed above for state i and year t, and ε_{it} = error term.

Standard t-tests and F-tests are used to determine which combination of independent variables has the best explanatory power. Statistical significance for β_1 and β_2 indicates that regional income inequality is primarily determined by the level of development in each state, as measured by per capita real income. As such, per capita income is expected to capture the long-run development trend. Convergence is indicated if $\beta_1 > 0$ and β_2 =/< 0 or if β_1 =/< 0 and $\beta_2 > 0$. Divergence is indicated if $\beta_1 < 0$ and β_2 =/> 0 or if β_1 =/> 0 and $\beta_2 < 0$. The geographic size of each state, as proxied by the number of counties, is captured by β_3, with expectations that $\beta_3 > 0$. Interpretation of statistical significance for β_4, holding the other three variables constant, is expected to reveal short-run shocks to the long run trend. If the independent variables are based on short-run energy market, agricultural market, and macroeconomic shocks would imply that increasing regional income inequality in the 1970s is attributable to the unusual happenings during this decade. Statistical significance for β_1, β_2, β_3, and β_4 simultaneously would indicate that both short-run and long-run factors determine regional income inequality.

Hypothesized Causal Variables

Based on the previous discussion of neoclassical, export base, growth pole, cumulative causation, and growth pole cycle theories, four groups of explanatory variables can be identified as potential reasons for observed increases in regional inequality in the 1970s. All variables are national values.

Short-Run Macroeconomic Shocks. In order to capture the divergence of regional income inequality attributable to national economic conditions, 6 variables are identified. These variables are: the growth rate of Gross Domestic Product (*dGDP*), the unemployment rate (*UN*), the 3-month Treasury bill interest rate (*Tbill*), the percentage change in M2 (*dM2*), the percentage change in the Consumer Price Index (*dCPI*), and the change in the University of Michigan Index of Consumer Sentiment (*dCS*).

Short-Run Energy Market Shocks. Two variables are identified in a effort to capture the potentially disequilibrating effects on regional income inequality from shocks in the world petroleum market. These variables are: the energy component of the Consumer Price Index (*eCPI*) and total petroleum imports (*Pm*).

Short-Run Agricultural Market Shocks. Two variables are identified to capture potential effects on regional income inequality from shocks in the agricultural markets. These variables are: the food component of the Consumer Price Index (*fCPI*) and the ratio of prices received by farmers to prices paid by farmers (*PPI*).

Methodology

To test for the potential short-run instability sources of increasing regional income inequality, ordinary least squares regression techniques are used on pooled cross-section, time-series data encompassing regional income inequality estimates for all 50 states from 1969 to 2009. Based on previous analysis [1, 6] identifying the importance of real per capita state income and the number of counties in each state as explanatory variables, the following equation is estimated.

$$V_{it} = \alpha + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 CN_i + \beta_4 X_{it} + \varepsilon_{it} \quad (1)$$

where: V_{it} = a measure of regional income inequality for state *i* and year *t*, Y_{it} = state per capita real income in state *i* and year *t*, CN_i = the number of counties in state *i*, X_t = one or more of the potential explanatory variables discussed above for year *t*, and ε_{it} = error term.

Standard t-tests and F-tests are used to determine which combination of independent variables has the best explanatory power. Statistical significance for β_1 and β_2 indicates that regional income inequality is primarily determined by the level of development in each state, as measured by per capita real income. As such, per capita income is expected to capture the long-run development trend. Convergence is indicated if $\beta_1 > 0$ and β_2 =/< 0 or if β_1 =/< 0 and $\beta_2 > 0$. Divergence is indicated if $\beta_1 < 0$ and β_2 =/> 0 or if β_1 =/> 0 and $\beta_2 < 0$. The geographic size of each state, as measured by the number of counties, is captured by β_3, with expectations that $\beta_3 > 0$. Interpretation of statistical significance for β_4, holding the other three variables constant, is expected to reveal short-run shocks to the long run trend. If the independent variables are based on short-run macroeconomic shocks would imply that increasing regional income inequality in the 1970s is may very well be attributable to the unusual happenings during that decade. Statistical significance for β_1, β_2, β_3, and β_4 simultaneously would indicate that both short-run and long-run factors determine regional income inequality.

Regression Results

The pooled cross-section, time-series data were initially used to estimate equation (1) with all X_t variables omitted. Results of this regression are:

$$V = \underset{(31.256)}{0.1129} + \underset{(3.048)}{0.0011Y} + \underset{(2.240)}{0.00001759Y^2} + \underset{(19.282)}{0.000580CN} \qquad (2)$$

$$R^2 = 0.250 \qquad F(3, 2046) = 227.891$$

This regression indicates that the number of counties, reflecting the size of each state, is highly significant in explaining regional income inequality within each state. The simple interpretation is that the larger the state, the greater the inequality of per capita income among counties. Moreover, this implies that the larger the state, the more time it takes for changes in regional income inequality to work their way through the regional economy. This also suggests that the measure of regional income inequality, like most statistical measures of variation is sensitive to the number of observations used for the calculation.

This regression equation further indicates that per capita real income is statistically significant in explaining regional income inequality. Regional income inequality unambiguously increases with an increase in income, indicated by the statistically significant value of the positive coefficient for *Y*. Moreover, it is increasing at an increasing rate, as indicated by the positive coefficient for Y^2. This suggests that, as a whole, regional income inequality has largely reached its minimum value and is not only on the path to divergence, but doing so at an accelerating pace.

This result for *intrastate* income inequality among counties within each state provides an interest contrast to Figure 1, which presents *interstate* income inequality among counties for the entire nation. While *interstate* income inequality leans more toward a picture of constancy from the mid-70s to the present, with only a slight indication of possible divergence, intrastate income inequality is much more suggestive of divergence. This result indicates that divergence has been occurring within each state, that is, some counties growing faster than others within a state, but overall each state is experiencing a similar process, that is, some states are *not* growing faster than others. Unbalanced growth within states, but more balanced growth among states. Whether or not this pattern continues remains to be seen.

Although t-tests indicate *Y* and *CN* are highly significant and the F-value indicates the equation is also highly significant, the R^2 indicates that only 25 percent of the variation is explained by these two variables. This leaves ample room to suggest that other factors, especially short-run macroeconomic shocks, might be relevant.

Figure 1: Interstate Regional Income Inequality: 1929-2011

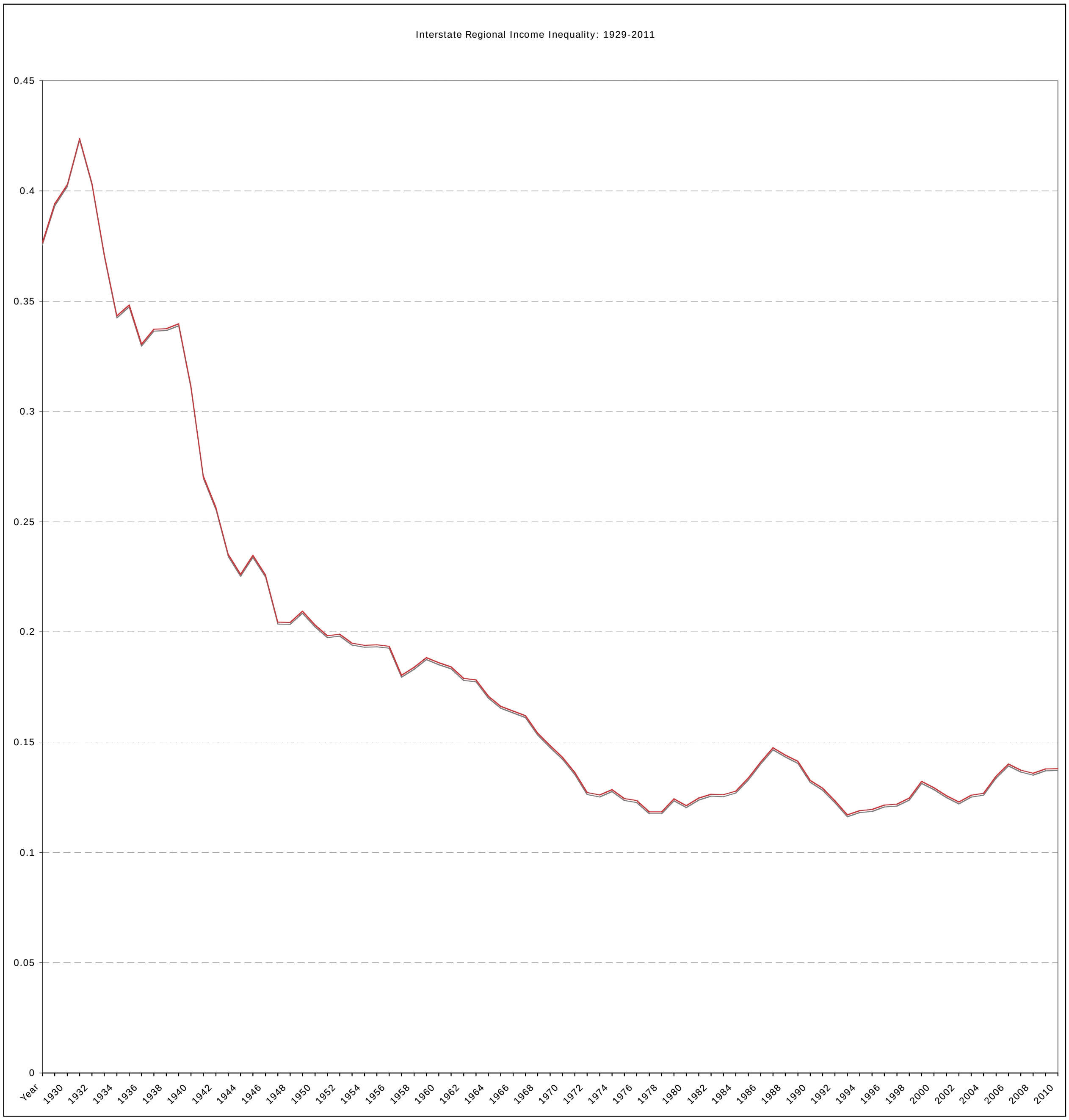

Table 1 Regression Results

Model	Constant (t-value)	Income (t-value)	$Income^2$ (t-value)	County (t-value)	Short-Run Variable (t-value)	R^2 (F-value)
Baseline	0.113 (31.296)*	0.0011 (3.048)*	0.0000176 (2.240)*	0.000468 (19.282)*		0.250 227.891*
Macroeconomic Variables						
Real GDP Growth Rate (*dGDP*)	0.109 (28.489)*	0.0009 (2.552)*	0.0000228 (2.840)*	0.000471 (19.401)*	0.0000151 (2.919)*	0.253 173.677*
Unemployment Rate (*UN*)	0.127 (22.754)*	0.0011 (3.112)*	0.0000162 (2.066)*	0.000467 (19.284)*	-0.0022199 (-3.233)*	0.254 174.322*
3-Month T-Bill Rate (*Tbill*)	0.101 (19.888)*	0.0011 (3.311)*	0.0000206 (2.603)*	0.001342 (19.471)*	0.0013421 (3.001)*	0.253 173.839*
M2 Growth Rate (*dM2*)	0.116 (20.484)*	0.0009 (2.446)*	0.0000197 (2.360)	0.000468 (19.275)*	-0.0002893 (-0.746)	0.251 171.020*
Change in CPI (*dCPI*)	0.114 (20.257)*	0.0011 (2.726)*	0.0000178 (2.205)*	0.000468 (19.259)*	-0.0000630 (-0.130)	0.250 170.841*
Change in Consumer Sentiment (*dCS*)	0.114 (30.956)*	0.0009 (2.656)*	0.0000202 (2.485)*	0.000469 (19.306)*	0.0000931 (1.241)	0.251 171.348*
Energy Variables						
Petroleum Imports (*Pm*)	0.117 (30.956)*	0.0020 (4.638)*	0.0000094 (1.148)	0.000478 (19.618)*	-0.0000084 (-3.623)*	0.255 175.214*
Energy CPI (*eCPI*)	0.119 (32.588)*	0.0020 (5.488)*	0.0000249 (3.196)*	0.000493 (20.276)*	-0.000281 (-7.499)*	0.271 189.592*
Agricultural Variables						
Parity Price Index (*PPI*)	0.113 (6.065)*	0.0011 (1.571)	0.00001776 (1.588)	0.000468 (19.177)*	-0.0000045 (-0.022)	0.250 170.835*
Food CPI (*fCPI*)	0.120 (32.633)*	0.0068 (8.259)*	-0.0000401 (-3.716)*	0.000513 (20.815)*	-0.0007183 (-7.672)*	0.271 190.470*

*Statistically significant at the 0.05 level.

Short-Run Macroeconomic Shocks

Tests for these potential short-run macroeconomics variables are summarized in first part of Table 1, which presents estimated coefficients and t-values for each variable when separately included into equation (1) with *Y*, Y^2, and *CN*. The six macroeconomic shock variables included are: growth rate of real GDP, the unemployment rate, 3-month Treasury bill rate, growth rate of the M2 money supply, change in the Consumer Price Index, and the change in the University of Michigan index of consumer sentiment. The baseline model with no additional variables is included for reference.

The first three macroeconomic shock variables (growth rate of real GDP (*dGDP*), the unemployment rate (*UN*), 3-month Treasury bill rate (*Tbill*)) are statistically significant at the 0.05 level and they all tell a similar story. An increase in the growth rate of real GDP, a decrease in the unemployment rate, and an increase in the 3-month Treasury bill rate all generate an increase in *intrastate* regional income inequality. That is, a business cycle expansion would lead to divergence and a business cycle contraction would lead to convergence. A business-cycle contraction thus could counter the long-run development pattern of divergence.

In each model significance of the short-run macroeconomic variable has no impact on the significance of income, income-squared, or the number of counties in the state with only modest changes in the coefficient values. As such, while short-run shocks might affect regional income inequality they do not supplant the basic long-run development explanation offered by the baseline model.

The three remaining short-run macroeconomic short variables in Table 1 (growth rate of the M2 money supply (*dM2*), change in the Consumer Price Index (*dCPI*), and the change in the University of Michigan index of consumer sentiment (*dCS*)) fall well short of the 0.05 level of statistical significance.

Based on the results in Table 1, two additional equations are estimated. The first is a comprehensive model containing all six variables. Results are:

V	=	0.118	+	0.00072*Y*	+	0.0000287Y^2	+	0.00047*CN*	(3)
		(12.408)		(1.670)		(3.123)		(19.514)	
	+	0.00052*dGDP*	-	0.00189*UN*	+	0.00243*Tbill*	-	0.00007*cCS*	
		(0.572)		(-2.174)		(3.610)		(-0.684)	
	-	0.00004*dM2*	-	0.00170*dCPI*					
		(-0.083)		(-2.204)					
R^2	=	0.260				*F* (9, 2040) = 79.836			

In this model, state per capita income (*Y*) falls below the 0.05 level of significance and surprisingly the change in the Consumer Price Index (*dCPI*), rises above the 0.05 level of significance as the growth rate of Real GDP also falls below the 0.05 level of significance.

Omitting the three short-run macroeconomic shock variables that fall short of the 0.05 level of significance results in the following estimated equation:

$$V = \underset{(17.385)}{0.122} + \underset{(1.730)}{0.00068Y} + \underset{(3.336)}{0.000029Y^2} + \underset{(19.523)}{0.00047CN} - \underset{(-3.135)}{0.00215UN} + \underset{(4.074)}{0.00243Tbill} - \underset{(-2.742)}{0.00177dCPI} \quad (4)$$

$R^2 = 0.260$ $\quad F(6, 2043) = 119.811$

The story told by Equation (4) is generally consistent with previous results, with a few noted qualifications. The negative sign on the coefficient for the unemployment (*UN*) and the positive sign on the coefficient of the 3-month Treasury bill rate (*Tbill*) both indicate that a business-cycle contraction contributes to convergence of *intrastate* income inequality, potentially countering a long-run divergence trend. One curious result is the negative sign on the coefficient of the change in the Consumer Price Index (*dCPI*). This indicates that a higher rate of inflation, something more closely associated with a business-cycle expansion would also contribute to convergence. And lastly it is notable that the statistical significance of the per capita income variable (*Y*) fell below the 0.05 level, although still above the 0.10 level. While this does not necessitate a reversal of earlier conclusions of the long-run divergence trend (per capita income squared remains highly significant), it does lessen the certainty of the results somewhat.

Short-Run Energy Shocks

Table 1 also presents the results for two energy sector related variables, petroleum imports (*Pm*) and the energy component of the Consumer Price Index (*eCPI*). Both short-run energy shock variables are statistically ignifycant at the 0.05 level when included separately with the baseline model. Both also have negative coefficients, indicating that an increase in either reduces *intrastate* regional income inequality or effectively contributes to convergence. The energy price shocks of the 1970s, rather than generating divergence, appears to have dampened any divergence that might have occurred.

One notable result is that the inclusion of petroleum imports into the baseline equation reduces the statistical significance level of the per capita income squared variable below the 0.05 level. However, per capita income itself remains positive and well above the 0.05 statistical significance level.

Including both short-run energy shock variables into the baseline equation generates the following result:

$$V = \underset{(32.201)}{0.122} + \underset{(6.268)}{0.00283Y} + \underset{(2.178)}{0.0000178Y^2} + \underset{(20.620)}{0.00050CN} - \underset{(-7.245)}{0.00027eCPI} - \underset{(-3.078)}{0.0000071Pm} \quad (5)$$

$R^2 = 0.274$ $\quad F(5, 2044) = 159.197$

Conclusions stated previously remain unchanged. Energy shocks, especially oil price increases such as those noted during the 1970s and surfacing to the lesser degree in the 2000s do not appear to be the source of regional income divergence. If anything, these events have worked to counter long-run divergence.

Short-Run Agricultural Shocks

The two remaining short-run shock variables presented in Table 1 capture activity in the agricultural sector. The parity price index (*PPI*) and the food component of the Consumer Price Index (*fCPI*) both have negative values, and while the food CPI is statistically significant at the 0.05 level, the parity price index is not. Curious that inclusion of the parity price index in the baseline equation also reduces the significance level of both per capita income and per capita income squared to below the 0.05 level.

Focusing on the food component of the CPI has a similar interpretation to the energy CPI variable. The negative value of the coefficient indicates that higher food prices reduce *intra-state* regional income inequality. Food price spikes, like energy price spikes, contribute to convergence rather than divergence.

Also notable is the change in the sign of the per capita income squared variable, turning from positive to negative.

Including both agricultural shock variables into the baseline equation generates the following results:

$$V = \underset{(9.252)}{0.189} + \underset{(6.640)}{0.00575Y} - \underset{(-1.851)}{0.0000222Y^2} + \underset{(20.860)}{0.00051CN} - \underset{(-8.421)}{0.00086fCPI} - \underset{(-3.426)}{0.000773PPI} \quad (6)$$

$$R^2 = 0.276 \qquad F(5, 2044) = 155.523$$

Again, the conclusions are effectively unchanged. Both short-run agricultural shock variables have negative coefficients. Higher food prices contribute to convergence rather than divergence. And while the t-value of the per capita income squared variable again turns negative, it remains statistically significant at the 0.05 level.

Short-Run Shocks: Combined Model

The last bit of analysis is to combine the three short-run shock models into a single model containing only those variables that are statistically significant. The results are:

$$V = \underset{(8.457)}{0.174} + \underset{(3.515)}{0.00345Y} + \underset{(1.468)}{0.0000204Y^2} + \underset{(21.004)}{0.00051CN} + \underset{(3.774)}{0.00180Tbill} - \underset{(-4.519)}{0.00023eCPI} - \underset{(-3.389)}{0.00076PPI} - \underset{(-3.380)}{0.00045fCPI} \quad (7)$$

$$R^2 = 0.285 \qquad F(7, 2042) = 115.998$$

The four short-run shock variables that are statistically significant at the 0.05 level are the 3-month Treasury bill rate (*Tbill*), the energy component of the Consumer Price Index (*eCPI*), the parity price index (*PPI*) and the food component of the Consumer Price Index (*fCPI*). As with preceding analyses, the *Tbill* coefficient is positive and the other three, *eCPI*, *PPI*, and *fCPI* are all negative. And while per capita income squared (Y^2) falls below the 0.05 statistically significance level, per capita income (*Y*) remains positive and statistically significant.

The primary conclusion is that long-run divergence, at least for *intrastate* income inequality, progresses with increased development. This divergence is reinforced by rising interest rates resulting from a business-cycle expansion, but countered by rising energy and food prices. Most important, there is not indication that short-run shocks to the economy is responsible for divergence of regional incomes.

Summary

Underlying causes of increasing regional income inequality observed for the United States since the 1970s remain unclear. The analysis contained in this study supports the proposition that regional income inequality increased due to a long-run development trend.

This supports the key implications of the growth pole cycle theory. The emergence of a new polarization phase in beginning in the later 1970s and continuing through into this century appears to be a primary source of the observed divergence of, or increase in, regional income inequality. And while several short-run shock variables affect regional income inequality, none supplant or replace the long-run trend captured by per capita income.

Business cycle expansions reinforce the long-run divergence trend, as indicated by the growth rate of real GDP, the unemployment rate, and the 3-month Treasury bill interest rate. This, however, is not inconsistent with the long-run development trend. Alternatively, energy sector shocks, especially petroleum imports and the energy component of the CPI, counter the long-run development trend. That is, higher energy prices and increased petroleum imports act toward convergence. Agricultural sector shocks tell much the same story, with the parity price index and food component of the CPI also tending to counter the long-run development trend. Higher food prices also more toward convergence. There is no evidence from this analysis that short-run shocks to the economy are the source of regional income divergence.

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An Analysis of Home Mortgage Foreclosures in Sioux Falls, South Dakota

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Abstract. In this paper we combine information from the Home Mortgage Disclosure Act (HMDA) data and original mortgage loan documents to investigate foreclosures in Sioux Falls, South Dakota, of loans made in 2007. Specifically, troubled loans as identified from court files are matched with corresponding records in the HMDA database to provide borrower and lender characteristics for further analysis. Combining the foreclosed loan records with those of loans which did not result in foreclosure proceedings, the research assesses the effect of lender, demographic, and neighborhood characteristics on the likelihood of foreclosure. Logit modeling revealed an important influence of both loan terms and demographic and neighborhood characteristics.

Introduction

After the 2008 financial collapse, foreclosure became a topic of heightened interest due to the general decrease in housing prices and an increasing number of defaults on home loans contributing to the problem. These defaults were in turn often linked to excessive subprime lending supported by securitization. The purpose of this research is to build a model for foreclosure starts in Sioux Falls, South Dakota, which will analyze the effect on foreclosure start of loan terms, subprime lending, and demographic and neighborhood characteristics.[1]

The research uses original loan information for each foreclosure that occurred in Sioux Falls between May 2007 and 2010. A match between this data and Home Mortgage Disclosure Act Data (HMDA data) from 2007 was attempted. Foreclosure was then predicted using a logit model with independent variables describing the characteristics of the mortgage, the borrower, and the property's neighborhood. The goal is to determine which characteristics had significant impact contributing to foreclosure.

This research is a companion piece to the research presented in Nesiba, Sorenson, and Sturm (2012), which identified which lenders in Sioux Falls have the highest numbers of foreclosures as well as which lenders had the highest foreclosure rates in Sioux Falls in 2007–2010. It also demonstrated that foreclosures have disproportionately affected low income and minority census tracts in Sioux Falls' inner core and northern neighborhoods.

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Review of Relevant Literature

Analysis of HMDA data to discern lending patterns, model application denial and possible discrimination, and, more recently, to assess foreclosures has generated a significant literature. Numerous studies analyzed the data in relation to redlining and discrimination, as typified by Munnell *et al.* (1996). In their logit model predicting whether a loan application was granted or not, the coefficient for race was large relative to other coefficients in the model and was statistically significant beyond the 1-percent level. Munnell *et al.* also ran OLS linear regressions that were consistent with the logit results. They constructed multiple logit models, but these were to predict loan acceptance, not foreclosure. They did find that minorities were more than twice as likely to be denied a mortgage as whites but noted the difficulties of making conclusions about race's affect on lending because HMDA data is missing credit worthiness variables.

Doviak and McDonald (2011), in their paper titled *Who Defaults? Who Goes into Foreclosure?,* analyzed mortgage default and foreclosure in New York State by matching New York State Banking Department data on foreclosures with HMDA data. Their analysis found strong racial disparities in lending practices, but they did not conclusively find that the measures of discrimination in HMDA data increased the probability of default. Doviak and McDonald also used a tobit model to estimate rate spread as a dependent variable. In their particular case, they reported that 81 percent of their HMDA data did not have a reported rate spread, and so the tobit model estimated the remaining portion.

Gerardi and Willen (2009) from the Federal Reserve Bank of Atlanta addressed the subprime mortgage crisis in urban neighborhoods in Massachusetts. The specific relevance of their research was the match made between Massachusetts Registry of Deed Offices and HMDA data. The Registry of Deed data did not come direct, but came instead from the Warren Group, a private corporation that collects property records. Gerardi and Willen described their matching process as follows:

> We merge mortgages in the deed-registry data with mortgages in the HMDA data between 1998 and 2006. The merge is based on the dollar amount of the mortgage, the Census tract where the borrower lives, the identity of the mortgage lender, whether the mortgage was a refinance or for a purchase, and finally the date of the mortgage.[16] We were able to match about 60 percent of the mortgages in the Massachusetts registry of deeds data (the population of mortgages) to the HMDA data each year. Considering that HMDA does not have perfect coverage of the mortgage market, the match rate is actually better than 60 percent. Furthermore, since we are not conducting a loan-level analysis, it is not the individually matched mortgages that we care about *per se*. Rather, we are conducting our analysis at the level of the ownership, and, thus, to obtain some of the time-invariant borrower characteristics from HMDA, such as race, we need only match one mortgage in the ownership. For example, if there is a homeowner who obtains three mortgages while living in the same property, in order to obtain the race of the household we only need to match one of the three mortgages (Gerardi, 2009, 9-10).

This matching process was the guideline for the research in this paper. Gerardi and Willen did not choose to make a logit model or run any regression at all. Their focus was on showing where subprime mortgages were occurring in Massachusetts and how unstable those have been. They concluded that subprime lending led not to an increase in homeownership by minorities, but generated turnover by minority residents.

Coulton *et al.* (2008) also provide an in-depth analysis of foreclosures, studying Cleveland and Cuyohoga County from 2005-2008. They also employed a matching technique focused on loan amount, census tract, and lender in matching HMDA records to local mortgage and court records. They were successful in matching about two-thirds of their HMDA data sample. Coulton *et al.* found significant effects in the expected direction of owner-occupied status, local vs. non-local lender, non-Hispanic black borrower, low- or moderate-income borrower, low home value, proximity to other foreclosures, and subprime lending, not necessarily by financial intermediaries designated as subprime lenders. Since all loans from the HMDA sample were matched to mortgages, providing the actual date of the loan, Coulton *et al.* were able to construct a hazard model and track foreclosure probabilities across time.

Foreclosure Model

Given the binary nature of foreclosure starts, a probability model is appropriate. While multiple-stage models could be investigated, we will focus on a reduced-form perspective, including characteristics of the loan, the lender, the borrower, and the neighborhood of the property. A key variable of interest is whether or not the lender is considered a subprime lender. Subprime loans typically include more burdensome loan terms, which may in turn increase the likelihood of foreclosure.

In addition to considering whether a loan was made by a subprime lender, explicit characteristics of the loan are relevant. The loan's interest rate, to the extent it is known, will also be included as an independent variable. Higher interest rates are expected to have a positive association with probability of default and foreclosure for two main reasons. First, higher rates presumably reflect lower credit scores and poorer past credit histories (although much debate has centered on whether these loans with less favorable terms have in many cases been provided to borrowers who may have qualified for 'prime' loans). Second, the greater the rate, the faster a mortgage can go "underwater," which can increase the chance of foreclosure if individuals walk away from loans and choose to foreclose. Interest rates will be considered in both continuous form, designated as the number of interest rates percentage points above a treasury security of the same term, and in binary format, i.e., whether or not the rate falls into the 'suprime' range of more than three percentage points higher than the treasury security.

Loan amount and the loan-to-income ratio are also included as independent variables. The most important, by far, is the loan-to-income ratio, which reflects the burden of loan payments on the borrower, increasing the probability of foreclosure. Higher loan amounts reflect higher payments, which could increase risk to some extent, although the risk could by mitigated by higher income levels and greater job security.

In addition to the loan and lender considerations, other variables incorporate borrower and neighborhood characteristics. Gender of the applicant and whether or not there is a co-applicant are both considered as potentially important independent variables. Gender, specifically whether or not the applicant is male, is included to reflect either a possible effect on loan terms or other effects on default likelihood based on the gender of the borrower. If any gender discrimination affecting loan terms exists, the effect on foreclosure probability of being male would be negative. Since there is no strong expectation about foreclosure probability unrelated to loan terms and the loan-term argument is tentative, the effect of a gender variable will be considered ambiguous. The presence of a co-applicant was predicted to have a negative effect on foreclosure. It should decrease the chance of foreclosure based on the idea that it provides more accountability and spreads out the risk of default.

Income and minority status were also included as possible important influences on the probability of foreclosure. Much like gender, these could be important as they affect the loan terms and as they might affect circumstances related to meeting loan obligations. Both income and minority status are included as they relate both to the individual borrower and to the neighborhood in which the property lies. In both the individual and neighborhood cases, higher income levels are expected to decrease the probability of default and minority status is expected to increase the probability of default.

Bringing together the influences on the probability of a foreclosure start, we can postulate the following simple model:

> Pr. (Foreclosure = 1) = f (subprime lender (+), loan-to-income ratio (+), subprime interest rate (+), loan amount; co-applicant (-), gender (?), applicant income (-), minority (+), tract median income (+), tract minority percentage (+), *error*)

The modeling itself will include two models. The first model will include the loan and lender characteristics, and the second will add the borrower characteristics.

Data Collection and Refinement

Foreclosure Data

Foreclosure records were gathered from the Minnehaha County Administration Building and Courthouse. We did this by linking announcements of pending lawsuits to their civil case numbers and recording mortgage note information from the corresponding case files. Through terminals in their office the Register of Deeds provides access to electronic scans of all released *lis pendens* beginning with those filed on or after May 17, 2007. From the *lis pendens* (an announcement of a pending lawsuit based on the borrower's failure to make payments that begins a public document trail), one can find the corresponding civil case number. Over a period of several months, lists of case files were given to the clerk of courts office. The staff pulled the individual files on these lawsuits and allowed us to examine these files within their office. The case file, a public record, contains the original note and mortgage documents — as well as the legal complaints, notices, summons, and judgments. We used these documents to construct an original and unique database with details of the note including: the originating lender, origination date, address of secured property, principal amount, whether the foreclosure was dismissed or sold by the Sheriff (and if so to whom and for how much), first payment date, last payment date, payment amount (initial payments for variable notes), whether the interest rate was fixed or variable (if variable, then to what it was linked), prepayment penalties, late charges, borrower(s), and other specifics about the note or case.

Information was gathered for all of Minnehaha County from May 17, 2007, through May 12, 2010, to create three years of continuous foreclosure start data. The original set of 1,115 foreclosure actions collected from case files was pared down to a working database of 777 mostly-matched observations by 1) collapsing any multiple-action properties to a single record, designating the foreclosure status as dismissed if none of the proceeding against the homeowners resulted in a Sheriff's sale; and 2) excluding any records from census tracts with significant areas extending outside the city limits of Sioux Falls. The City of Sioux Falls assisted us in this effort by geocoding our foreclosure database addresses to specific census tracts and block groups. The resulting dataset was subsequently pared down by eliminating any mortgages that originated prior to 2004. An attempt was made to match as many of the loans as possible to HMDA entries using the census tract (adjusting for 2000 to 2010 changes), loan amount, year, lender, and applicant/co-applicant gender. The majority of loans were matched on a one-to-one basis, but numerous non-matched cases existed. Some of the cases had no corresponding loan by any lender in the HMDA data; some had multiple loans by the lender identified in the foreclosure data with similar origination amounts; and some had loans that matched in amount, year and census tract, but with a different lender. In many cases, we were able to identify a match using trade name/corporate name pairings (e.g., America's Wholesale Lender/Countrywide), but in numerous other cases no full match existed. Ultimately, foreclosures with no clear matching HMDA record were deleted, and, whenever multiple possible bank/year/loan amount combinations, with or without additional applicant/co-applicant matches, existed, the HMDA records were deleted.

More than four hundred foreclosures were matched using the procedure described above. However, given the May 2007 cut-off as the earliest reported *lis pendens* records and the relatively short time-span for loans made in 2008 and later, the database was limited to 2007 loans only. It may be possible in the future to continue gathering additional data and reduce the presence of missing data between the HMDA and foreclosure files, but the absence of machine-readable *lis pendens* prior to May of 2007 would require an even more labor-intensive process than the one used to create this original foreclosure dataset.

The full HMDA dataset of Minnehaha County loans made in 2007 included over eight thousand observations, but the dataset was limited to less than three thousand loans after eliminating Farm Service Agency and Rural Housing Service loans and home equity lines, including only owner-occupied single-family housing first-lien mortgages with values between $50,000 and $500,000, and keeping only Sioux Falls census tracts. One additional observation, with a loan-to-income ratio far greater than any other loan, was deleted, generating the final dataset of 2,625 loans, of which 62 experienced foreclosure starts by 2010.

Independent Variables

The independent variables, with the exception of subprime lender, were drawn or created from the HMDA data. Applicant income, like loan amount, is expressed in hundreds of dollars. Loan-to-income ratio was simply constructed by dividing income into loan amount.

The HMDA data reports the rate spread, i.e., increment above a comparable treasury security, only when the spread exceeds three percentage points, so it is available for only a small portion of the loans. A binary variable, here termed 'subprime interest rate' is a variable constructed to indicate whether the rate increment above a comparable treasury security was at least three percentage points or not. It is termed subprime interest rate to reflect the fact that the three-percent threshold is used in identifying subprime lenders. The loan-to-income ratio (LIR) was also examined in binary format to see whether particular thresholds might be meaningful.

Subprime lender designation was based on Department of Housing and Urban Development (HUD) lender characterization. For a number of years, HUD maintained an official list designating which banks specialize in subprime lending, using a number of criteria, including the presence of interest rates significantly above a treasury security of similar term. We make use of the 2005 list, the most recent available.

Census tract minority percentage and tract median income as a percentage of Sioux Falls MSA median income, our measure of neighborhood income, are provided directly on the HMDA data for the year 2000 census. The co-applicant and minority variables required some manipulation. To determine if there existed a co-applicant, the HMDA co-applicant gender variable, sorted into applicable and not-applicable, was used. HMDA indicates Hispanic vs. non-Hispanic in one variable and allows for a set of racial designations in another variable. For racial minorities, we used only the first race indicated for the applicant and focused on the Native American and Black groups, excluding the smaller Asian American and Hawaiian/Pacific Islander groups. Given the small number of minority borrowers, we also created a single combined minority variable for use in the logit models.

Descriptive Statistics

Descriptive statistics are found in Tables 1 and 2. Table 1 provides means and proportions of the variables considered in the foreclosure modeling, presenting the statistics for the overall group, the foreclosure start group, and the non-foreclosed loans. The dependent variable, foreclosure start, has a value of 1 for 2.36% of the observations. Given the much larger percentage of non-foreclosed loans, overall means and proportions are quite close to the non-foreclosed values, so the discussion will focus on any contrasts between the groups.

Table 1. Descriptive Statistics.

Numerical Variables:		Full Sample	Foreclosure Starts	Non-Foreclosures
Loan Amount	Mean	138.44	129.60	138.65
	Std. Deviation	58.10	84.09	57.33
	Range	[50,500]	[50,500]	[50,492]
	n	2625	62	2563
Applicant Income	Mean	66.12	57.42	66.34
	Std. Deviation	49.59	50.23	49.57
	Range	[10,675]	[12,240]	[10,675]
Loan-to-Income Ratio	Mean	2.51	2.84	2.50
	Std. Deviation	1.01	1.27	1.01
	Range	[0.15,7.67]	[0.81,6.44]	[0.15,7.67]
Rate Spread	Mean	4.62	4.99	4.58
	Std. Deviation	1.45	1.71	1.42
	Range	[3,11.8]	[3,7.33]	[3,11.8]
	n	238	20	218
Census Tract Minority %	Mean	7.65	11.06	7.57
	Std. Deviation	5.25	6.63	5.19
	Range	[2.15,23.71]	[2.15,23.71]	[2.15,23.71]
Tract Median Income as % of SF	Mean	110.76	98.18	111.06
	Std. Deviation	24.73	25.89	24.63
	Range	[71.99,159.51]	[71.99,159.51]	[71.99,159.51]

Binary Variables:	n	% of Full Sample	% of Foreclosure Starts	% of Non-Foreclosures
Foreclosure Start	2625	2.36%	100%	0%
Subprime Lender	2625	2.97%	4.84%	2.93%
Subprime Interest Rate	2625	9.07%	32.26%	8.51%
Loan-to-Income Ratio > 3	2488	27.65%	37.10%	27.41%
Loan-to-Income Ratio > 4	2488	8.20%	16.13%	8.00%
Loan-to-Income Ratio > 5	2488	1.85%	6.45%	1.73%
Applicant Hispanic	2503	1.84%	8.20%	1.68%
Applicant a Racial Minority	2473	1.90%	6.56%	1.78%
Applicant a Minority	2469	3.65%	14.75%	3.36%
Applicant Male	2530	68.62%	62.30%	68.77%
Coapplicant	2569	50.84%	30.65%	51.34%

Average loan amounts and borrower incomes differ by about $10,000 between the two groups, with average loan values around $140,000 and incomes around $65,000 in our sample. When loan-to-income ratios are computed, we find that the foreclosed loans average about ten percent higher (2.84 vs. 2.5), with a lower standard deviation (but wider range) for the non-foreclosed loans. Average rate spread, i.e., the increment above a comparable treasury security, reported only when the spread exceeds three percentage points, is higher for the foreclosed loans, but by less than one-half of one percentage point. The small number of observations on which the loan rate spread averages are based limits the value of this variable for analysis. It is worth noting that non-foreclosed loans range up to 11.8 percentage points higher than the treasury security, even higher than the least favorable foreclosed loan.

The census tract variables reveal notable differences among the foreclosed and non-foreclosed averages. The average minority percentage for the foreclosed loans was about eleven percent, while the non-foreclosed average was about 7.5%. The tract median income for the foreclosed loans was slightly below total MSA median income, while the median for non-foreclosed loans was more than ten percent above the MSA median. For both measures, the range was the same for both foreclosure groups, indicating foreclosures and non-foreclosed loans in the extreme cases of both minority percentage and median income.

The binary variables in Table 1 reveal much more notable differences between the two groups. Subprime lender percentages were not high for either group, but the foreclosed loan percentage was considerably higher than the non-foreclosed percentage (4.8% vs. 2.9%). As for subprime interest rate, regardless of whether a loan was made by a subprime lender, almost a third of the foreclosed loans carried the higher interest rate, compared to less than one-tenth of the non-foreclosed loans. More than a third of the foreclosed loans had an LIR greater than three, but so did more than a quarter of non-foreclosed loans. Sharper differences occur at LIRs above four and five, where we note that twice the percentage of foreclosed loans had LIRs above four (16.1% vs. 8%), and almost four times the percentage of foreclosed loans (6.4% vs. 1.7%) had LIRs above five.

Turning to the traits of borrowers, we examined racial and ethnic characteristics of the applicant, gender of the applicant, and whether or not there was a co-applicant. Hispanic borrowers constituted over eight percent of the foreclosures, but only 1.7% of non-foreclosed borrowers. Racial-minority borrowers constituted 6.6% of the foreclosed loans but only 1.8% of non-foreclosures. When either Hispanic origin or other minority status existed, termed simply ‘minority’ here, we find that almost fifteen percent of foreclosures involved minority borrowers, compared to only 3.4% of non-foreclosures.

Male applicants constituted around two-thirds of the cases, although some of the disparity could simply be the listing of the male partner of a couple first on the loan application. There is some difference between the two groups, with male applicants constituting 62.3% of foreclosed loans and 68.8% of non-foreclosed loans. Finally, co-applicant varies dramatically between the two groups. While about half of the non-foreclosures were loans with a co-applicant, only about a third of the foreclosures had a co-applicant.

The number of observations indicated in the binary variable section of Table 1 are also worth noting, as they alert us to the fact that some observations do not include complete information. We are therefore dealing with missing values in many cases, which will lead to some slight differences in the total number of observations and in modeling results. We do not believe that these are major differences. Fortunately, the vast majority of 'lost' observations are for non-foreclosures, so very few of already-limited foreclosure observations are lost in subsequent modeling.

Table 2 offers a different perspective by assessing the percentages of loans with particular characteristics, or to borrowers with certain characteristics, that went into foreclosure proceedings. For each of the characteristics, we show the number of loans with the characteristic, the number that ended up in foreclosure proceedings, and the percentage foreclosed, along with the relative risk (percentage with the characteristic foreclosed ÷ percentage without the characteristic foreclosed) and the associated odds ratio, which is typically very close to relative risk with the low percentages typical of these variables.

Table 2. Percentage of Loans Foreclosed by Loan and Borrower Characteristic.

Loan Characteristics:	# of loans	Foreclosed	% Foreclosed	Relative Risk	Odds Ratio
Subprime Interest Rate	238	20	8.4	4.77	5.12
Loan-to-Income Ratio>3	688	23	3.34	1.54	1.56
Loan-to-Income Ratio>4	204	10	4.9	2.15	2.21
Loan-to-Income Ratio>5	46	4	8.7	3.66	3.91
Loan from Subprime Lender	78	3	3.85	1.66	1.69
Borrower Characteristics:	# of loans	Foreclosed	% Foreclosed	Relative Risk	Odds Ratio
Gender Male	1736	38	2.19	0.76	0.75
Co-applicant	1306	19	1.45	0.48	0.47
Hispanic	46	5	10.87	4.77	5.23
Racial Minority	47	4	8.51	3.62	3.87
Minority	90	9	10	4.57	4.96

Loans with subprime interest rates went into foreclosure 8.4% of the time. While this is not a high percentage, it is almost five times the percentage of loans that did not have subprime interest rates. Loans with LIRs above three went into foreclosure 3.3% of the time, which is 1.5 times the percentage for lower LIRs. When the LIR rose above four, the foreclosure percentage rises to about five percent (more than twice that for lower LIRs), and when the LIR was above five almost nine percent of loans went into foreclosure (more than three times that for lower LIRs). Loans from subprime lenders went into foreclosure almost four percent of the time, a rate 1.66 times that for non-subprime lenders.

Loans with male applicants went into foreclosure just over two percent of the time, which is only 0.76 times the percentage for female applicants. About 1.5% of loans with co-applicants went into foreclosure, which is less than half the rate of loans without co-applicants. Loans to Hispanic borrowers went into foreclosure almost eleven percent of the time, almost five times the rate of non-Hispanic borrowers. The racial minority percentage (8.5%) and relative risk (3.62) were somewhat lower, and the combined minority percentage was exactly ten percent, or about 4.56 times the non-minority rate.

Modeling and Results

Two logit models were run based on the specification mentioned. Model 1, based on only the loan and lender characteristics, revealed the importance of the loan-to-income ratio and the binary 'subprime interest rate' indicator of whether the interest rate spread exceeded three percentage points (Table 3). The coefficients were of the expected positive sign and significant at the 0.005 level. When controlling for LIR and interest rate, the subprime lender variable takes a negative sign, decreasing the likelihood of a foreclosure start, but it is not significant. Loan amount has a negative coefficient, but is not significant. The model McFadden ρ^2 is a quite low 0.071, indicating much remaining unexplained variation. This is consistent with the Gamma and Somers' D measures reflecting 35-40% reduction in pairwise prediction errors and the c measure indicating that in 68% of crossed foreclosure/non-foreclosure pairs the model correctly predicted a higher probability for the foreclosure observation.

Table 3. Logit Model Results.

	Model 1		*Model 2*	
Intercept	-4.6304	***	-5.8061	***
	<.0001		*<.0001*	
Loan Amount	-0.00279		0.0003	
	0.2748		*0.9265*	
Loan-to-Income Ratio	0.3796	***	0.3906	**
	0.0014		*0.0143*	
Subprime Lender	-1.0279		-0.7589	
	0.1108		*0.2539*	
Subprime Interest Rate	1.9945	***	1.8208	***
	<.0001		*<.0001*	
Applicant Income			0.0053	
			0.1196	
Minority Borrower			1.3247	***
			0.0010	
Male Applicant			-0.1444	
			0.6132	
Coapplicant			-0.4516	
			0.1678	
Tract Median Income as % of SF			-0.0012	
			0.8911	
Census Tract Minority %			0.0868	***
			0.0094	
Somers' D	0.367		0.536	
Gamma	0.384		0.552	
c	0.683		0.768	
ρ^2	0.071		0.119	
n	2488		2329	

Notes: ***, **, and * indicate 0.01, 0.05, and 0.10 two-tailed significance, respectively.
Italicized numbers are Wald χ^2 statistic p-values.

The second model (Model 2 of Table 3) added the borrower and tract characteristics to the model. When the new variables are added, the LIR and interest rate variables maintain their statistical significance and have coefficients similar to those in the simpler model. The minority variables, both individual and tract percentage, both enter as significant positive influences on foreclosure start probability. Applicant income has a positive coefficient and tract income has a negative coefficient, but neither is statistically significant. Both male gender and presence of a co-applicant have negative coefficients, but neither is statistically significant.

Odds ratios for the models are shown in Table 4. Focusing on the full model (Model 2) and significant variables, we see that an increase of one in the loan-to-income ratio increases by about fifty percent. The odds of a foreclosure start for subprime interest rates are more are more than six times those with lower rates, with an upper confidence interval bound approaching twelve and a lower bound of 3.26. The odds of a foreclosure start for minority borrowers are on average 3.76 times those of non-minorities, with lower and upper confidence bounds of 1.71 and 8.29 times. A one-percentage point increase in census tract minority percentage on average raises the foreclosure odds by about nine percent, with confidence bounds between 2.2 and 16.5 percent.

Table 4. Odds Ratios.

	Model 1			Model 2		
Variable:	*Point Estimate*	*Lower Bound*	*Upper Bound*	*Point Estimate*	*Lower Bound*	*Upper Bound*
Loan Amount	0.995	0.989	1.001	1.000	0.994	1.006
Loan-to-Income Ratio	1.643	1.247	2.165	1.478	1.081	2.020
Subprime Lender	0.362	0.102	1.283	0.468	0.127	1.724
Subprime Interest Rate	7.592	4.150	13.889	6.177	3.264	11.690
Applicant Income				1.005	0.999	1.012
Minority Borrower				3.761	1.706	8.292
Male Applicant				0.866	0.494	1.515
Coapplicant				0.637	0.335	1.209
Tract Median Income %				0.999	0.981	1.017
Census Tract Minority %				1.091	1.022	1.165

Foreclosure likelihood is further illustrated in Table 5, which provides a set of loan/borrower profiles and associated probabilities of default. The first profile, labeled "typical," uses the mean of continuous variables and the more common category of binary variables, adjusted so that loan amount, income, and LIR are consistent. In this case, the foreclosure start probability is 0.016, close to the overall incidence of foreclosure in the data set. The "high risk" case uses the minimum values of the income and loan amounts, generating a high LIR, has a high interest rate, and designates a minority female applicant, without a co-applicant, living in the lowest income, highest minority census tract. In this case the foreclosure start probability rate rises to 0.791, higher than any of the empirically predicted foreclosure probabilities in the dataset. The "low risk" case designates favorable loan terms, reverses the minority, gender, and co-applicant variables, and sets the census tract values to the other extreme, generating a foreclosure start probability of 0.006. Finally, a "mixed" case is generated to examine foreclosure probability with poor loan terms for a female applicant without a co-applicant, but not demographic and neighborhood characteristics associated with more likely foreclosure. In this case, the probability rises to only 0.12, emphasizing the additional large influence of the demographic and neighborhood variables.

Table 5. Predicted Foreclosure Probabilities for Selected Hypothetical Loan/Lender/Borrower Profiles.

	Model	*Descriptive Statistics*		*Profiles*			
	Parameter	*Mean*	*Range*	*Typical*	*High Risk*	*Low Risk*	*Mixed*
Loan Amount	0.0003	138.44	[50,500]	138.44	50	200	138.44
Loan-to-Income Ratio	0.3906	2.511	[0.15,7.67]	2.51	5	2	3
Subprime Lender	-0.7589	0.030	[0,1]	0	0	0	0
Subprime Interest Rate	1.8208	0.091	[0,1]	0	1	0	1
Applicant Income	0.0053	66.12	[10,675]	55.1	10	100	46.2
Minority Borrower	1.3247	0.037	[0,1]	0	1	0	0
Male Applicant	-0.1444	0.686	[0,1]	1	0	1	0
Coapplicant	-0.4516	0.508	[0,1]	0	0	1	0
Tract Income as % of SF	-0.0012	110.76	[71.99,159.51]	110.76	71.99	159.51	110.76
Census Tract Minority %	0.0868	7.650	[2.15,23.71]	7.65	23.71	2.15	7.65
Probability of Foreclosure Start				0.016	0.791	0.006	0.119

Conclusion

This research proved fruitful in illustrating the relationship between foreclosure starts and loan, borrower, and neighborhood characteristics. Perhaps the key finding is the importance of loan terms, especially high interest rates, rather than any simple association with subprime lenders. Although relatively few minority borrowers are included in the dataset, reflective of the smaller minority presence in Sioux Falls when compared to larger metropolitan areas, the logit modeling clearly illustrates an increased foreclosure probability for minority borrowers.

Several useful extensions to the model could offer additional insight. We have not differentiated among lenders other than the subprime lender distinction. One could incorporate information about the size and location of the lenders as another possible source of foreclosure probability. A continuous measurement of interest rate, perhaps employing tobit modeling to estimate censored values, might also be included. More importantly, the model would benefit from extending the foreclosure database back in time, so that earlier years' worth of data could be added. As more time for foreclosure incidence passes, it may also be feasible to add 2008 data.

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Executive Summary. The Rocky Mountain Region of the USDA-Forest Service (Forest Service) and the State Demography Office within the Colorado Department of Local Affairs (DOLA) have worked collaboratively since 1994 to collect data and provide analysis on the economies of Colorado counties. More recently, the Forest Service and DOLA have worked to improve methods for conducting "economic base analysis" and the understanding of these analyses. A current interest is whether classic economic impact multipliers may be extended to include the effects of 1) capital formation and 2) local government spending.

This study examined that question from two perspectives. First, the theory and the merits of deriving multipliers to include these effects was considered and, second, practical approaches were developed and demonstrated using the IMPLAN modeling system. Two practical approaches were developed for estimating the change in multipliers: 1) local government spending was internalizing in an IMPLAN model customized with primary data and, alternatively, 2) an approximation technique for internalizing local government spending was used with a conventionally-defined IMPLAN model. Three counties containing National Forest System lands in Colorado – Otero, Pueblo, and Summit – were used to demonstrate the two options.

Economic multipliers closed for capital investment (mainly construction) in small "regional" economies have been discussed extensively over the last 50 years. Construction is often prominent in small regions, affecting many regional industries. Nevertheless, a consensus has emerged that closure for construction is not appropriate in a regional input-output (I-O) model for three reasons. First, the linkage between saving and investment at the regional level is weak at best. It is rare that regional saving would be sufficient to provide the funds for capital construction; capital markets are national and often international. If construction were included, the resulting multipliers would mistakenly imply that regional saving drives regional construction. Second, capital investment is a long-term decision affecting modes of production while an I-O model represents the short term during which capital is fixed. The third reason is a practical consideration. Estimates of saving at all levels are notoriously inaccurate. Regional models often take advantage of this data weakness by using the capital account as a catch-all for residual discrepancies in the model. When all three reasons are considered, the inclusion of capital investment in economic multipliers has little merit and would diminish their credibility.

In contrast to capital, local government spending is an excellent candidate for closure in a regional I-O model because of the strong relationships between local government fiscal and local business ac-

tivities. For this study, primary data were collected from 73 local governments in the three counties. The analysis excluded local school districts because school funding levels are driven by demographic factors, often substantially supported by state transfers, and therefore not well correlated with local business activity.

To examine the effect of local government spending on multipliers, an IMPLAN model was built for each county, customized to isolate local governments and describe their spending with primary data. Each model was run with and without inclusion of local governments in the multipliers. On average, multipliers including local governments increased by one percent in Otero and Pueblo Counties. In Summit County, multipliers increased by three percent. While the increase was more than three times larger than in Otero and Pueblo Counties, this would not be enough to compel analysts to replace conventionally-defined multipliers. The story for Summit County, however, is not in averages, but in specific industries.

Multipliers for specific industries increased up to nine percent. The reason for larger increases rests with a considerable tourism industry. Because Summit County is an internationally-recognized resort destination, local government operations provide services to not only local residents, but also a large visitor population. A large source of revenues for these services is indirect business taxes paid by tourism-related sectors – e.g. retail trade, auto rental, and lodging. These same sectors are among the largest payers of indirect business taxes per dollar of sales. Consequently, when combining the magnitude of tourism-related sectors with high payments of indirect business taxes and sizable government spending, the added induced effect to multipliers becomes noteworthy. Under these conditions, multipliers that only account for household spending are likely to understate the induced effect for tourism-based industries.

The approximation methodology examined in this study did not yield results that could substitute for a complete model customization. However, the methodology is inexpensive and offers a relative indicator of industry linkages with local government operations. It may offer a suitable, albeit conservative, approximation of multipliers for tourism-based industries where local government operation spending is included in the induced effect.

Introduction

The Problem

The Rocky Mountain Region of the USDA-Forest Service (Forest Service) and the State Demography Office within the Colorado Department of Local Affairs (DOLA) have worked collaboratively since 1994 to collect data and provide analytical information about the economies of Colorado counties. These products have been used by elected officials and agency personnel of Federal, state, and local governments to improve understanding of their local economies and how they respond to change.

Forest Service interest has focused on the distribution and magnitude of local economic changes prompted by forest land and resource management plans (forest plans), large scale projects, and administrative decisions. Consequently, these products not only informed the public and government officials about the local economy, but also played important roles in decision-making.

One key set of analytical products used for these purposes has been economic "base analyses". These analyses identify the fundamental economic engines that "drive" the local economy. Hence, they also have been referred to as economic "driver analyses."

Two different approaches have been used to conduct these analyses. DOLA has used a traditional base-export approach combined with RIMS II (Regional Input-Output Modeling System, version 2) multipliers from the Bureau of Economic Analysis to identify the number and magnitude of the fundamental industries. The Forest Service has used IMPLAN, a proprietary input-output modeling system, to accomplish the same thing.

In recent years, the Forest Service and DOLA have worked to improve understanding and methodologies for these analyses. Two areas of current interest include the relationship and estimation of 1) capital formation – that is, construction of structures and purchase of durable goods – and 2) local government spending in classic economic multipliers. This study examines the theoretical merits of including these economic activities in the derivation of multipliers and the applied options for using IMPLAN to estimate the multipliers. Options include 1) collecting primary data on government operations and "closing" the Leontief inverse for such spending and 2) an alternative methodology that uses a more traditional input-output (I-O) formulation of "closing" for households only.

For clarification, the inclusion of local government spending in the *multiplier effects of private industries* is distinct from estimating the effects of local government spending. The multiplier effects of private industries are those that *start* with production by a given industry. Depending on how the multiplier is defined, the effects may include consequences to households and/or local governments. This is contrasted with multiplier effects that *start* with government spending. Techniques and results of modeling effects that start with government spending are not discussed in this study.

Three counties containing National Forest System lands are used to demonstrate the results of the two options.

The Analysis Area

The Rocky Mountain Region consists of eleven administrative units that manage National Forests and National Grasslands in Colorado, Wyoming, South Dakota, Nebraska, and Kansas. There are eight units with lands in Colorado covering 16.0 million acres in 45 counties. Thus, out of 64 counties in Colorado, 70 percent contain lands managed by the National Forest System (NFS).

Colorado counties with NFS lands range from urban centers along the Front Range (e.g. Boulder, El Paso, Jefferson, Larimer, and Pueblo) to the smallest, most rural counties in the state (e.g. San Juan, Hinsdale, and Baca). They also range from some of the highest median household incomes in the nation (e.g. Douglas ranked 6th) to some of the poorest (e.g. Costilla ranked 2nd).[1] Their economies range from strong dependence upon traditional resource-based industries in rural areas to destination tourism in mountain resort areas and to technology and professional services (e.g. health, legal, management) in urban areas.[2]

Six counties were originally selected to represent the variety of economic conditions noted above. However, the cost of collecting and organizing primary financial data from local governments and customizing IMPLAN models with the data proved greater than expected. The

[1] U.S. Census Bureau. Small Area Income and Poverty Estimates for 2009. http://www.census.gov/cgi-bin/saipe/saipe.cgi accessed on February 24, 2011.

[2] State Demography Office, Division of Local Governments, Colorado Department of Local Affairs. 2011. Economic Base Analysis. https://dola.colorado.gov/demog_webapps/eba_parameters.jsf accessed on February 24, 2011.

number of test counties was subsequently reduced to three. They are listed in Table 1.

Table 1. Counties selected for IMPLAN model customization and approximation of multipliers using alternative methodologies.

Setting	Geography	County	Median Household Income (2008)	Economic Dependence
Rural	Eastern Plains	Otero	$33,234	Agriculture
Mountain Resort	I-70 Corridor	Summit	$64,813	Tourism
Urban	Front Range	Pueblo	$42,005	Government, Professional services

Source: Census Bureau, State and County QuickFacts (http://quickfacts.census.gov/qfd/states/08/08009.html) ;
Colorado Department of Local Affairs, State Demography Office, Regional Socio-Economic Profiles (http://dola.colorado.gov/dlg/demog/region_profiles.html)

The Modeling System

IMPLAN is a secondary data, input-output modeling system. The system was first developed by the USDA-Forest Service in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management during the late 1970's. The system includes both data and software. In 1987, data generation for IMPLAN was provided by the University of Minnesota. In 1993, MIG, Inc was formed to privatize the development of IMPLAN data and software.

IMPLAN software is designed for a range of users from modeling novices to academic leaders.

It has evolved over the years in response to both technology advances and user needs. Version 1 of the software was released in 1996, Version 2 in 1999, and Version 3 in 2009. The latest edition of the software provides advanced features for model customization and introduces multi-regional input-output capabilities.

IMPLAN datasets are prepared annually using the latest economic data that are publicly available. Unique datasets are available by county for the entire U.S., with data by zip codes available upon request. Data from a variety of Federal sources are reconciled to provide a consistent set of estimates that can be aggregated to state and national levels. Proprietary techniques are used to estimate data that can not be disclosed because of Federal confidentiality requirements, allowing users to publish detailed study results using IMPLAN. Proprietary estimates of trade flows for 440 commodities between all U.S. counties are key to the creation of credible, local models using the system.

IMPLAN has gone from a system used by a few Federal agencies to one that is embraced by economists throughout the U.S. IMPLAN has been used by over 250 academic institutions across the country, including Yale, Stanford, Duke, University of Michigan, and University of California-Berkeley. In addition, over 200 Federal, state, and local government agencies have used IMPLAN. With the inclusion of private firms and non-profit organizations, the IMPLAN client list is extensive. Hundreds of publications have referenced IMPLAN, ranging from peer-reviewed academic journals to local economic development newsletters. MIG, Inc. hosts a conference for IMPLAN users every other year in conjunction with the annual conference for the Mid-Continent Regional Science Association. Proceedings from past conferences are available at www.implan.com.

Theory of Multipliers Derived from I-O Models

General

The term economic "multiplier" has become virtually a household word in recent years. News media coverage of arguments both for and against Federal government spending, or "stimulus", has included references to its "multiplier" effect. What is an economic "multiplier"?

The multiplier is classically defined as "a change in income divided by the change in investment that caused it."[3] The concept is generally credited to Keynes as he considered aggregate changes and their consequences in a large economy. Because Keynes dealt with large-scale aggregates, the results were also expressed in aggregates. Such aggregate multipliers may be valuable for national economic policy decisions, but their ambiguity limits practical applications at smaller scales. [4] Regional economics, therefore, borrows this concept and gives it specificity in numerous ways that are useful at state and sub-state levels. Rather than general macroeconomic multipliers at a national scale, regional multipliers can be determined for each sector of a local economy. Multipliers for the bio-fuels industry, for example, are quite different from those for the health care industry. Economic multipliers may be developed for output, employment, labor income, and value added. These measures can be valuable for examining policy scenarios or market-driven events, such as economic development, government spending, workforce layoffs, and tourism.

One of the most common tools of the regional economics discipline is the input-output (I-O) model. I-O models use a matrix to map transactions between industries occurring in the region, and then manipulate that matrix to estimate economic multipliers.[5] A more inclusive mapping, called a social accounting matrix, incorporates transactions between all parties in the economy, not just those between industries. Resident households, governments, and parties located outside the region are all considered to fully account for exchanges occurring throughout the economy. The full accounting offers a valuable portrayal of the regional economy, but I-O models are most often used to identify economy-wide consequences of spending changes. By comparing all the new spending in the economy to the initial spending change, a multiplier is defined. For instance, if $1 million of new production in one industry ultimately generates $1.5 million of production throughout an economy, the multiplier is 1.5.

While knowing the total economic consequences – or total effect – of a given action is valuable, it may be even more valuable to know components of the effect. The total effect can be broken down into three distinct components: *direct, indirect, and induced*. Direct effects are those experienced in the industry that makes the initial sale of new goods and services. Indirect effects are those experienced by all local industries that supply inputs into the production process of the directly-affected industry. These effects include not only the sup-

[3] Smith, Warren L. 1971. Macroeconomics. Richard D. Irwin, Inc. Homewood, Illinois. p. 117.

[4] Miernyk, William H. 1965. The Elements of Input-Output Analysis. In The Web Book of Regional Science (www.rri.wvu.edu/regscweb.htm). ed., Randall W. Jackson. Morgantown, WV: Regional Research Institute, West Virginia University, 2008. p. 42.

[5] Numerous references in this report offer excellent explanations of the Leontief inverse which yields output multipliers. The term "multiplier matrix" will be used in lieu of Leontief inverse, or $(I\text{-}A)^{-1}$.

ply chain of the directly-affected industry, but the supply chain of all supporting industries as well. All "rounds" of support are summed up in the indirect effect. Induced effects are those experienced by all local industries that provide goods and services to households which received labor income in direct or indirectly-affected industries. From increased payrolls, local households increase their spending on goods and services. Some of the increased demand for goods and services is met by local firms. To produce these goods, local firms need inputs from other local firms, creating another cascading effect similar to the supply-chain consequences captured in indirect effects. Once the cascading effect has run its course, the induced effect is complete. Because both indirect (or supply-chain) effects and induced (or labor income) effects are based on inputs in the production process, they are often referred to as "backward" linkages. It is important to note that indirect effects are always caused by demand from a local industry and induced effects are always caused by demand from a local non-industry entity, such as households.

The multiplier effect is based on the injection of new spending in an economy. This new spending must originate from sources outside the industrial interactions within the economy. Outside sources, often called "institutions", include the following:

- Households
- Governments
- Capital Investment
- Exports

The first two institutions represent entities physically located in the region. Households include all residents of the region, and Governments include all local, state, and federal governments and their agencies located in the region. Capital Investment may be regarded as a fund that purchases structures and durable goods, such as industrial equipment, which are both produced in and imported into the region. Individual entities that "participate" in Capital Investment purchases may not be identifiable. Exports include purchases from the local economy by all institutions and businesses located outside the region.

These four institutions make up what is called *final demand* (FD). Households, Governments, Capital Investment, and Exports are the *final users* of goods and services produced in the regional economy. Parties located outside of the region that purchase goods and services made locally may indeed use them to produce other goods and services, but from the *perspective of the region* these non-local parties are the final user. The spending behavior of institutions is regarded as *independent* of and the catalyst for all industry transactions or general business activity that takes place in the region.

Sales by industries in a region may be to institutions (i.e. final users) or they may be to other businesses in the region as part of their supply chain. Just as sales to final users satisfy *final demand*, sales to other businesses satisfy *intermediate demand*. Total production by a business satisfies either final demand or intermediate demand.

Multipliers are determined by the number and magnitude of transactions in the region required to meet final demand. These transactions, in turn, are determined by the input mix required by each industry and the share of those inputs acquired with the region. As the number of industries present within a region increases, the size of multipliers generally increase. Similarly, as the share of inputs acquired within a region increases, the size of multipliers generally increases. Large, urban regions of the U.S. generally have the greatest number of industries. They also have industrial production levels that can meet the needs of local customers. Thus, the largest multipliers are generally found in a model of the entire U.S. Conversely, the smallest multipliers are generally found in small, rural areas.

Starting with a complete set of transactions, the multiplier matrix (or Leontief inverse) can be specified in a variety of ways. Each specification yields a different set of multipliers.

First, the multiplier matrix only includes transactions among industries. When inter-industry transactions are the only ones included in the multiplier matrix, it is referred to as "open." See Figure 1. The only effects available from this model are direct and indirect. Secondly, Households can be redefined and moved from independent Final Demand (referred to as *exogenous* elements of the model) to dependent Intermediate Demand (the *endogenous* elements of the model). When Households are included in the multiplier matrix, the model is referred to as "closed" with respect to Households. See Figure 2.

Figure 1. An "Open" Input-Output Model

Type of Demand	*Intermediate*	*Final*				*Total*
Industries or Institutions→ ↓	Industries	Households	Governments	Capital Investment	Exports	Total Output
Industries	**Backward Linkage = Indirect Effect**					
Households						
Governments						
Saving						
Imports						
Total Outlay						

Figure 2. An Input-Output Model closed with respect to Households

Type of Demand	*Intermediate*		*Final*			*Total*
Industries or Institutions→ ↓	Industries	Households	Governments	Capital Investment	Exports	Total Output
Industries	Backward Linkage = Indirect Effect					
Households		Backward Linkage = Induced Effect				
Governments						
Saving						
Imports						
Total Outlay						

With the inclusion of households, induced effects (that is, effects attributed to an institution in the multiplier matrix) are now added to direct and indirect in comprising the whole or total effects. Including Households in the multiplier matrix is the most common specification of I-O models.

Two reasons can be cited for the popularity for this specification among regional economists. First, labor is a major input into the production process of most industries. This move recognizes the strong connection between industry production and payrolls. Second, Households receive a significant portion of their income by selling their labor. Household income, in turn, plays a major role in determining household spending, which includes the demand for local goods and services. By including households and their labor income in the multiplier matrix, these strong interactions are included in the economy's total response to industrial production.

The purpose of this report is to examine the merits and practical aspects of including two other institutions in the multiplier matrix: capital investment and local governments. These will be discussed in the next two sub-sections.

Before moving to the merits of including other institutions in the multiplier matrix, several characteristics of I-O models should be noted.

1. Input-output multipliers have no time dimension. I-O models are designed as short-term models, built with annual

data and annual flows of dollars throughout the region. They may be considered an economic "snapshot" of a region for a given year. When a model is "shocked" with changes in Final Demand, the effects are assumed to occur quickly – within a year or so.

2. A modeled economy is considered to be in equilibrium. When the modeled is "shocked", it moves from its current equilibrium to a new state of equilibrium. For example, whatever condition the workforce and labor force are in will continue in the new state of equilibrium. Unemployment rates in effect during the model year will not change with the introduction of a production "shock". Model users, however, may utilize model results to address potential changes in unemployment. This is an interpretation or application exercise of model results, rather than a simple reporting of model results.
3. I-O models represent annual dollar flows, not accumulated stocks. The net wealth of a region or the value of its infrastructure will not be found within a social accounting matrix. Only annual income to industries and institutions is represented in the model.
4. There are no supply constraints when a regional economy expands. Goods, services, labor, and capital are available without limit. The model will grow a local industry to meet new local demands.
5. I-O models are linear. All relationships are held constant (constant returns to scale) regardless of the size of "shocks" to the region.
6. Prices throughout the modeled region are assumed to be fixed. That is, they will not change in response to a change in demand.
7. Finally, an I-O model represents a single production function and a fixed technology for each industry. There are no substitutions or updated technologies when a region responds to changes of final demand.

Despite these limitations of input-output models, they have proven to be valuable tools in understanding the nature of regional economies and are used across the world.

Capital

In the previous sub-section, it was noted that multipliers have three components: direct, indirect, and induced effects. The composition and magnitude of the induced component is determined solely by the institutions removed from final demand and included in intermediate demand. The institution becomes part of the multiplier matrix. The previous sub-section also noted that the Household institution is generally included in I-O models because their economic behavior is strongly connected with business activity in a region. The question before us is whether Capital Investment is also a good candidate for model "closure". If so, final demand for a region would shrink as Capital is removed and multipliers would increase as Capital is added.

Why consider Capital for model "closure"? First, construction is a large and visible piece of the local economy in many parts of Colorado. In some mountain counties, construction is integral to resort and real estate development. As resort communities grow, construction also grows and becomes more diverse. In urban counties, construction is seen as a function of robust business activity. The demand for office buildings, manufacturing plants, and light industry parks expands as general economic growth occurs. In the parts of Colorado that attract retirees, construction occurs to provide new housing and improved health care facilities.

Given these strong ties of construction to core economic activities, the inclusion of Capital Investment in multipliers is a reasonable expectation.

Second, construction often affects many sectors within a local economy. Goods and services required by the construction process are often supplied by local firms. Concrete, gravel, electricity, vehicle repair, trucking services, welders, and common supplies through wholesalers are examples of construction inputs often acquired locally. To omit these important linkages from multiplier effects may be viewed as incomplete analyses.

Third, large construction projects often bring a transient workforce to host communities. Visiting workers spend some portion of their labor income locally for housing, food, clothing, gasoline, vehicle repair, and entertainment. This spending can provide a substantial boost to sectors that sell primarily to households.

The inclusion of Capital Investment in multipliers is not a new idea. Economists have explored the idea for decades.[6] The current literature on capital and I-O models points us to three issues that must be addressed before closing an input-output model for Capital Investment. The issues are:

1. Relationship between saving and investment in a region
2. Time frame for effects (short-term v long-term)
3. Reliability of data
    a. NIPA - saving
    b. IMPLAN - capital

Students of Macroeconomics 101 may recall the simple Keynesian equivalence S=I. Total saving in an economy must equal total investment. Saving is the annual accumulation of financial capital throughout the economy set aside by households, businesses, and governments. For households, it is defined as annual after-tax income not used for current consumption. For incorporated businesses, it is defined as undistributed profits. For all businesses, depreciation is also a form of saving designed to replace existing capital. For governments, saving is defined as current receipts less expenditures. All transfer payments, such as social security and Medicare, are included in government expenditures. When government expenditures exceed receipts, saving is negative and borrowing is necessary. Saving must be distinguished from savings (plural). Savings is the stock of funds accumulated by these institutions over time. Because I-O models capture annual dollar flows, total savings – and estimates of net worth – are outside the model.

Investment is the private sector expenditure of financial capital to create fixed capital used in production, including both structures and durable goods. Structures include the construction of buildings and infrastructure, such as homes, offices, manufacturing plants, marinas, and parking lots. The drilling of oil and gas wells for both exploration and production are also counted as investment by the private sector. Durable goods include items such as machines, electronics, tools, and vehicles. Whether structures or durable goods, these inputs to the production process are not consumed in a single year, but provide years of service.

In the National Income and Product Accounts, the economic accounting standard for the U.S., investment does not include either consumer or government spending on structures or durables goods. Although both these institutions spend funds on infrastructure and goods that last well beyond a year, they are by definition not engaged in the production of

[6] Richardson, Harry W. 1972. Input-Output and Regional Economics. Weidenfeld and Nicolson. London, UK. Pp 183-193.

goods and services in the economy. Households and governments contribute to national saving (or dis-saving) and do so in hopes of a return on investment in the private sector, but none of their expenditures are considered in the national accounting of investment. All such expenditures are regarded as current consumption expenditures. I-O models follow this convention.

It has been said that closing an I-O model with respect to saving and investment implicitly assumes that investment is driven by saving. [7] Indeed, saving provides the funds necessary for investment throughout the economy. When considering the entire U.S. economy, the equivalence S=I is solid (except for foreign investment from places like China). Saving from anywhere within the country is made available for investment at any other location within the country through credit markets. At a regional level, however, that relationship starts to weaken. Saving within the region may not be sufficient to support the demand for financial capital within the region. Credit markets step in to provide financial capital from other parts of the country, and indeed the world. As a region gets smaller, such as a single county, the relationship is further weakened. At this very small scale, investment may have little or no relationship to saving acquired from within the same county. Outside sources are required to meet local demand for financial capital. Because local investment behavior is not well correlated with local savings behavior, the argument for closure of Capital Investment in small, regional I-O models is weak at best.

[7] Kratena, Kurt and Gerhard Streiker. No Date. "Macroeconomic Input-Output Modeling – Structures, Functional Forms and Closure Rules". Austrian Institute of Economic Research at www.wifo.ac.at. p. 27.

The second issue is one of harmonizing long-term relationships inherent in investments with short-term relationships inherent in I-O models. Populated by transaction data for a given year, I-O models map the consumption of goods and services to meet final demands within the same time period. While I-O models do not explicitly specify the time required to move from its current state to a new one after a change in final demands, it is generally held that effects play out very quickly. This is in contrast to the life of investments which by definition are not consumed in a single year, but contribute to production over multiple years. In response to the need for long-term models, economists have created a variety of dynamic economic models with explicit time dimensions.[8] [9] While further discussion of dynamic modeling is beyond the scope of this work, it strongly suggests that basic I-O models are inappropriate tools to address the relationship of Capital Investment to short-term changes in final demand. One economist, though focusing on the topic of economic growth, comments on the use of classic short-term models to address capital investment:

> "There appears to be complete unanimity…that the relation of capital formation to growth cannot be treated by the conventional tools of short-run economics. We appear to agree that, by definition, we are dealing with problems of rates of change over time rather than with short-period equilibrium; and that continuing changes in capacity, technique, and taste—normally treated

[8] There are numerous publications on the topic, including: Leontief, Wassily. 1986. "The Dynamic Inverse" (1970) in Input-Output Economics. Oxford University Press. New York, NY.

[9] Kurz, Heinz D. and Neri Salvidori. 1998. "The Dynamic Leontief Model and the Theory of Endogenous Growth." Presented at the Twelfth International Conference on Input-Output Techniques. New York, NY. P.3.

> exogenously in modern economic theory, or in once-over change exercises—must somehow be introduced endogenously."[10]

To restate, this economist concludes that short-term models are not the tools to satisfy the aspiration for making capital investment responsive to regional economic activity. Again, there is a poor match of investment behavior with model characteristics. The long-standing recognition of this mismatch argues against the inclusion of Capital Investment in the multiplier matrix of I-O models.

The final issue regarding Capital and I-O models is a more practical one. Even if one ignores the issue of saving and investment equivalence in small regions and ignores the issue of conflicting time periods between long-term investment and short-term models, could reliable data be obtained from available sources? The answer is no. It has been said, "Existing statistics on saving have a bad reputation among economists... There is probably no other concept for which U.S. official agencies issue annual estimates that differ by more than one-third, as they have done for net household saving. And there is probably no other concept for which reputable scholars claim that the correct measure is close to ten times the officially published one."[11] As noted earlier, definitions of saving and investment are simple in theory, but complex in current conventions. Saving is not measured directly, but as a residual. For example, household saving is determined by subtracting estimates of consumption from those of income. Consumption estimates are generally considered quite reliable, but estimates of income are difficult to obtain and subject to substantial error.[12] This means that household saving can change dramatically as income estimates are revised over time.

Saving estimates are difficult to ascertain at the national level, but they become even more challenging at local levels. IMPLAN reconciles published economic data for a county from a variety of sources that are estimated in a variety of ways. Any reconciliation process, no matter how robust it may be, requires a location that must absorb residual differences. For IMPLAN that location is the Capital institution. Given the inherent weakness of saving and investment estimates in the National Income and Product Accounts, it is reasonable to use Capital as a final resting place for residuals. In this way, the strengths of other institutions are retained.

Returning to the three issues above, it is clear that "closing" an I-O model for Capital Investment is not recommended. On all three counts -- saving and investment inequality at the local level, the inappropriateness of representing long-term relationships in a short-term model, and weak data on saving and investment – the case for making Capital, with its components of construction and durable goods, endogenous cannot be made. Hoover and Giaritanni stated it clearly when they wrote that "a short-run regional model should certainly treat investment as primarily an exogenous or basic element."[13]

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[10] Rowtow, W. W. 1955. "Some General Reflections on Capital Formation and Economic Growth" in Capital Formation and Economic Growth. Princeton University Press. Princeton, NJ. Pp. 635.

[11] Lipsey, Rober E. and Helen Stone Tice. 1989. "Introduction" in The Measurement of Saving, Investment, and Wealth. The University of Chicago Press. Chicago, IL. pp. 1-2.

[12] U.S. Department of Commerce, Bureau of Economic Analysis. 2007. Measuring the Economy: A Primer on GDP and the National Income and Product Accounts. Washington, DC. p. 11.

[13] M. Hoover and Frank Giarratani. 3rd edition, 1984. An Introduction to Regional Economics. In *The Web Book of Regional Science*

Government

In the National Income and Product Accounts, government is a component of final demand. Like households, it is a final user of goods and services. The question here is whether government consumption behavior is strongly related to business activity, and therefore a good candidate for inclusion in the multiplier matrix. The same characteristics discussed above for Capital Investment are relevant for a determination on closure with respect to government. Stated differently: Is there a sufficient relationship between government spending and business activity within the region in the short-term to merit a shift of government from its traditional position outside the multiplier matrix (exogenous) to inside the matrix (endogenous)? Secondly, is there sufficient data to support a credible analysis in such a model?

Before proceeding, it is important to note that the topic here is government consumption spending, not investment spending or transfer payments. Expenditures on infrastructure, durable goods, and software are investments. Social Security, Medicare, and Medicaid are transfers payments to households, and considered supplements to their income. Government consumption includes those goods and services required for the implementation of government programs – utilities, gasoline, air fare, office supplies, food, contract labor, and so forth. Government consumption is therefore only a portion of total government expenditures.

The answer to the first question above is dependent upon the level and function of government being considered. For any small region in the U.S., Federal government consumption behavior in the region does not typically respond to changes in business activity. Demand by the Federal government for local goods and services, regardless of function, is independent of business activities and revenues collected from those activities. Political decisions may be made nationally to increase Federal purchases of goods and services produced in certain localities, sometimes in part because of local economic conditions. However, these policies are often counter-cyclical, responding with increased Federal purchases when local economies are depressed. The endogenous components of I-O models respond to changing conditions with additional changes in the same direction, not the opposing direction. Federal government behavior, regardless of function – defense or discretionary, may be the poorest candidate for closure in I-O models.

State government consumption behavior may be a better candidate for closure in regions than the Federal government. State programs may respond to a variety of needs at the local level. Highway maintenance and motor vehicle licensing offices are examples of state spending that sometimes increase locally with growing business activity. But other state spending behavior may not move in concert with business changes. Major state facilities such as prisons and colleges, where state demand for local goods and services may be a sizable portion of total demand, often respond to statewide conditions rather than local conditions. Given this variability, many I-O practitioners close their models for state government when the model area is an entire state, but keep state government exogenous when analyzing sub-state regions.[14]

(www.rri.wvu.edu/regscweb.htm), ed., Scott Loveridge. Morgantown, WV: Regional Research Institute, West Virginia University, 1999. Section 11.3.2.

[14] A good example is McDonald, L.A., H.W. Bender, E. Hurley, S. Donnelly, and D.T. Taylor. 2007. *Oil and Gas Economic Impact Analysis*. Prepared for the Colorado Energy Research Institute, Colorado School of Mines. Booz|Allen|Hamilton, Greenwood Village, CO, Report 2007-1, June 2007.

Local government consumption behavior is a good candidate for closure in small model areas. Because local government jurisdictions are generally small, they act more quickly and directly in response to constituent households and businesses. Businesses that see increased production and sales also pay more property, sales, and use taxes. These taxes are a critical source of local government revenues. Excluding revenues from the sale of government enterprises – like utilities, hospitals, and mass transit – and transfers from state and Federal governments, property, sales, and use taxes account for 82 percent of local government revenues across the U.S.[15] Unlike Federal and state governments, local government operational expenditures are often limited legally to current revenues. Thus, greater business activity means greater tax revenues, which often translates into greater consumptive spending by local governments as they increase a variety of local services. These strong, short-term relationships make local governments an excellent candidate for model closure.

While these strong relationships are characteristic of local governments, not all functions behave equally. Some functions of local governments are strongly influenced by transfer payments from state and Federal governments. A good example is local education. Traditionally, school districts are funded by local property taxes. But over the years, many states have increasingly supplemented school budgets, especially in low income communities. Nationally, school districts receive 56% of their revenues from state or Federal sources.[16] School district in 27 states average more than the national average, exceeding 80 percent in Hawaii, Vermont, Arkansas, and New Mexico. Thus, while local government generally is highly reliant upon local revenue sources for its consumption spending, it is not consistent across all functions of local government.

Are there reliable data for modeling local governments in I-O models? Yes. Unlike investment and saving, there are excellent sources of government revenues and expenditures. The foremost source is the Census of Government Finance provided by the U.S. Census Bureau. A complete census of state and local governments every five years and sample-based surveys in intervening years provides a wealth of reliable data that are widely used by analysts and economists.

In summary, local government is the only level of government which merits serious consideration in the derivation of multipliers from I-O models for small regions. With some exceptions, spending behaviors relate well to revenue streams, which in turn are based on local business activity. State governments are not good candidates for small regions, but may be considered when the region is an entire state. The Federal government is never a good candidate when modeling small regions.

Conclusion

Among the components of final demand considered here, capital investment (i.e. construction and durable goods) should never be moved from exogenous to endogenous elements of an I-O model. This is true for investment in the public as well as private sector. Among governments, only local government merits consideration. Like resident households, local governments receive a substantial portion of their income from local sources and their consumptive spending to provide many services is often limited to current revenues. However, some functions of local government, like educa-

[15] U.S. Census Bureau. 2010. 2008 Annual Survey of State and Local Government Finances. Washington, DC.

[16] U.S. Census Bureau. 2010. 2008 Annual Survey of Local Government Finances - School Systems.

tion, may be an exception to this characterization.

Procedures for Deriving Multipliers Inclusive of Local Governments

With the dismissal of Capital, the focus of this study turns to local governments in multipliers derived from IMPLAN models. To accomplish this, two IMPLAN models of each test area were created. The first was a standard model using default IMPLAN data and specifications (closed for households). This model provided a basis for customization and for the approximation methodology. The second was a customized model using primary data from local government financial documents and closing the model for households and local governments.

Customizing IMPLAN

For over a decade, the Rocky Mountain Region of the Forest Service has modified IMPLAN models in Colorado to match employment estimates by industry published by DOLA. Output and value added estimates by industry were modified based on "per job" relationships established by IMPLAN for the model area. Industry production functions, regional purchase coefficients, payroll requirements per dollar of production, and household spending patterns were not edited as part of the modification.[17] These unmodified elements of the IMPLAN model are the fundamental determinants of output and other multipliers. Because the focus of this study was the comparison of multipliers with and without the inclusion of capital and/or local governments, this type of modification of IMPLAN models was not necessary. However, a more demanding customization of the government institutions and industries in IMPLAN was required.

IMPLAN structure

IMPLAN data and model structure recognizes three entities: industries, institutions, and factors of production. *Industries* are generally private sector entities defined by the North American Industrial Classification System (NAICS). In addition to 426 industries in the private sector, ten industries are defined to capture government activities in the marketplace: three Federal and three state and local government enterprises, plus two Federal and two state and local government labor industries. Government enterprises are government-based organizations that sell goods and services to households and businesses in a market transaction, intending to recover all or most costs of production.[18] At the local level, they are often providers of mass transit and publicly-owned utilities, such as water, sewer, and electricity. Government labor industries are model creations which hold employment, payroll, and depreciation components of government operations.

IMPLAN identifies twenty *institutions* in each model: nine household income groups, three Federal government groups, three state and local government groups, and five other non-industrial consumers of goods and services. The final use of goods and services may be consumed locally by households or governments, they may be consumed locally to create fixed capital (e.g. buildings), they may be exported to parties outside the local economy, or they may be added to inventories awaiting future sale.

[17] Customization of an IMPLAN model based on DOLA employment estimates typically results in small adjustments of industry size and composition. Fundamental trade relationships are generally unaffected.

[18] Baker, Bruce E. and Pamela A. Kelly. 2008. A Primer on BEA's Government Accounts. Survey of Current Business. U.S. Department of Commerce, Bureau of Economic Analysis. Washington, D.C. 88(3):29-38.

Finally, IMPLAN identifies four *factors* of production: employee compensation, proprietors' income, other property type income, and indirect business taxes. The first three are payments made for the use of land, labor, management, and capital. The last one is a draw upon "other property type income" to fund government services. Although the term "indirect business taxes" originated from sales and use taxes, this factor includes all types of taxes as well as miscellaneous payments to governments for things such as fines, fees, and permits.

The IMPLAN system does not allow additions to industries, factors, or institutions. A local economy may not contain some industries, but it always contains all institutions and factors of production. Further, the IMPLAN system treats state and local governments as an inseparable combination. Limitations in national data sets do not permit the full and detailed separation of state from local governments at the county level. These constraints pose a challenge when seeking to isolate local governments and including their response in local economic multipliers.

To overcome these limitations in the IMPLAN system -- while also retaining the many benefits of the system, one must 1) redefine the relevant institutions and industries and 2) replace IMPLAN data with data from other sources. Redefinition and replacement are discussed next in terms of data and model specification.

Redefinition and Data Replacement

In the IMPLAN system, Institution 12001 includes all state and local government functions, other than education and investment. It was assumed that data provided by IMPLAN accurately represented the sum of state and local government transactions for each study area. In the customized model, 12001 was redefined to include only local general governments. Primary data was collected from local government financial documents, organized to be consistent with input-output conventions, and entered in IMPLAN study area data tables. These primary data were subtracted from IMPLAN data for state and local governments, assuming that the balance represented only state government transactions. The balance was added to Institution 11001, Federal government, other than defense and investment. Consequently, 11001 was redefined to include both Federal government (excluding defense and investment) plus state government (excluding education and investment).

Primary data were used to estimate local government commodity production, total final demand, and transfers among institutions. Because detailed commodity purchases by local governments are not available in published financial documents, total commodity purchases (total final demand) were estimated as a residual. IMPLAN estimates of state and local government purchases were assumed to be representative of local government purchase patterns. Total commodity purchases by local governments were then allocated among specific commodities by using the purchase pattern provided by the IMPLAN data. Primary data on transfer payments to local households (e.g. welfare and employee retirement annuity payments managed by local governments) were allocated among household income groups in a similar manner, using IMPLAN data for household transfers by state and local governments as a distributional pattern. Commodity production was modified to the extent it was evident in the primary data.

Industry 437 is a unique industry that holds employment, payrolls, and depreciation for state and local general governments. Industry 437 was redefined as local governments only, with primary data replacing existing IMPLAN estimates. The balance of employment, payrolls, and depreciation were added to Industry 439, making that industry a combination of Federal government, non-defense and state government, non-education.

The final adjustments were made to government enterprises. There are three state and local government enterprises in IMPLAN: Industry 430, Passenger Transit; Industry 431, Electric Utilities; and Industry 432, Other Enterprises. Where primary local government data indicated that passenger transit and electricity generation/distribution were present, the enterprises were modified for employment, payrolls, and depreciation. Industry purchase patterns of commodity inputs were unchanged, but balanced using standard IMPLAN software features.

In the test counties, water and sewer services dominated enterprise activities. To account for this dominance in the model, Industry 428, an unused Federal enterprise sector, was converted to represent only water and sewer enterprise operations in the test counties. Industry 432 was modified to exclude water and sewer services. In addition, commodity inputs purchased by Industry 428 were edited to mimic private sector water and sewer operations using coefficients from Industry 33, Water, Sewage, and Other Treatment and Delivery Systems. Other Property Type Income and Indirect Business Taxes were adjusted to reflect public ownership. Other enterprise activities in the primary data were folded into local government operations.

Model Creation

Version 3 of IMPLAN was used to create the customized model. Several steps both in and outside the software were required to incorporate primary data and redefine institutions and industries.

Prior to creating the customized model, the "multiplier" tab in User Preferences was edited. In addition to all household institutions, "State/Local Govt NonEducation" was selected. "Enterprises (Corporations)" was automatically included when "State/Local Govt NonEducation" was selected to account for corporate income tax payments to state government. Because "State/Local Govt NonEducation" has been redefined to include only local governments, "Enterprises (Corporations)" was unchecked. This specification included all households and local governments in the model's multiplier calculations. It also included three factors: employee compensation, proprietors' income, and indirect business taxes. Indirect business taxes provide the critical link between business activity as a source of local government revenues and subsequent government spending. Because home ownership in both the BEA's national input-output model and IMPLAN's modeling system is treated as a business, residential property taxes are captured in the link.

The model was created through study area data only using standard IMPLAN data files. Once the model was created, the model file was opened using MS Access. In MS Access the appropriate study area data tables were modified, and then the file closed. Returning to IMPLAN, the model was created through social accounts. Government and enterprise industries were modified using customizing features in the software. Trade flows were adjusted to align the supply and demand of local government payroll and enterprise industries. Finally, the model was constructed through multipliers.

Multiplier Approximations Using Response Coefficients

Model customization is an expensive endeavor that typically is not affordable by most parties. Therefore, an alternative methodology was sought that is less demanding technically and less costly than model customization, yet offers a credible approximation of multipliers from the customized model.

The alternative methodology can be expressed as follows for the output multiplier:

$$(I-A)^{-1}_{HH+LG} \approx ((\text{Direct Output} + \text{Indirect Output} + \text{Induced Output})_{HH} + (\text{IBT/Output} * \text{IBT to LG/IBT} * \text{LG Spending/IBT to LG} * \text{Total Output/LG Spending})) / \text{Direct Output}$$

Where,

1) $(I-A)^{-1}_{HH+LG}$ is the output multiplier when the model is closed with respect to households and local governments (the customized model)
2) $(\text{Direct Output + Indirect Output + Induced Output})_{HH}$ are the total output effects per $1 of production when the model is closed with respect to households only
3) IBT/Output is the SAM multiplier of indirect business taxes (sum of all indirect business taxes generated per $1 of production)
4) IBT to LG/IBT is the share of total indirect business taxes distributed to local governments in the SAM
5) LG spending/IBT to LG is the relationship of total local government spending on goods & services per dollar of indirect business taxes received
6) Total output/LG spending is the total effects in terms of output of spending $1 by local governments on goods & services
7) Direct Output is $1 of production

This methodology posits that the interactions of local government spending included in the customized model may not be substantially different from accounting for only the initial round of local government spending financed by local tax receipts.

Some discussion of terms 2 through 6 in the equation may be useful. Term 2 is the numerator of a conventionally-defined output multiplier. Term 3 is the SAM multiplier for indirect business taxes (IBT) in the default IMPLAN model. Generally throughout the US, but especially in Colorado, local government spending can only occur when local government revenues are supplied. In the IMPLAN model, IBT is the primary link between local business activity and government revenues. Each industry in the model pays a unique share of its production costs to IBT. For example, retailers across the U.S. typically pay 15 percent of every dollar of production costs (excluding the cost of goods sold) to IBT, while the telecommunication firms pay 8 percent, and food processors pay less than 1 percent. In addition to these direct payments, the supply-chain of one industry may collectively pay a relatively large share of its outlays to IBT, while another supply-chain pays little. Both the direct and supply-chain payments to IBT are expressed in the IBT multipliers calculated by IMPLAN. The IBT multiplier is defined as total changes in IBT throughout the model area divided by direct changes in IBT per million dollars of production. Each IMPLAN model provides a report of indirect business tax effects per million dollars of output and the resulting multipliers for every industry in the model area.

Terms 4 and 5 focus on the revenues and expenditures of local governments. These terms cannot be estimated from IMPLAN, since local government receipts and spending cannot be separated from combined state and local totals. However, when terms 4 and 5 are multiplied, they simplify to "local government spending per dollar of IBT". Now only an estimate of local government spending is required to complete the calculation.

The Census Bureau's Census of Government Finance (CGF) provides such an estimate. While national and state summaries are available at www.census.gov, individual government responses are not shown. However, data, metadata, and explanatory documents that cover individual jurisdictional responses to the CGF are available upon request from the Census Bureau.[19]

There are three issues with CGF response data: currency, coverage, and accounting period. All issues are related to the Census Bureau's survey program. Only in the years ending with "2" or "7" is there a complete census of local governments. During the intermediate years, local governments are statistically sampled to provide statewide estimates of total local government revenues and expenditures. It is unlikely that data for all local governments within a particular study area will be available in years other than the decennial census. The accounting period issue stems from diverse fiscal years among local governments. During the survey year, governments are asked to report financial data for their most recent fiscal year that ended between July 1 of the previous year and June 30 of the survey year. Hence, survey year 2007 covers individual government fiscal years that ended from July 1, 2006 through June 30, 2007. The resulting Census Bureau statistics for survey year 2007 are labeled as fiscal year 2007. For those governments using a calendar year, data reported during the 2007 census was actually for fiscal year 2006. Because of the intractable cost and time required, the Census Bureau does not attempt to standardize the accounting period for reporting purposes. Most local general governments in Colorado use a calendar year as their fiscal year, although it is not universal. For the approximation methodology, 2007 CFG results offered the most comprehensive, detailed, readily available, and low cost source of financial data for local governments. The one-year difference between the analysis year and CFG data was adjusted by inflating CFG data using BEA's price index for state and local government consumption expenditures[20].

Using metadata and explanatory documents, a crosswalk was created for Census expense definitions with IMPLAN institution and enterprise definitions. Applying the crosswalk to Census data files yielded an estimate of local government current operation expenses. Excluded from current operations are assistance and subsidies, interest on debt, insurance benefits and repayments, capital outlays, and intergovernmental transfers[21]. The Census Bureau estimate of current operation expenditures and

[19] U.S. Census Bureau, Government Division, Outreach and Education Branch, govs.cms.inquiry@census.gov , 1-800-242-2184

[20] Bureau of Economic Analysis, Department of Commerce. 2011. Table 3.10.4. Price Indexes for Government Consumption Expenditures and General Government Gross Output. www.bea.gov. on January 26, 2011.

[21] U.S. Census Bureau. 2006. Government Finance and Employment Classification Manual. p 5-3.

the IMPLAN estimate of total IBT allow us to calculate the share of total IBT that is spent by local governments.

Thus, our equation is now

$$(I\text{-}A)^{-1}_{HH+LG} \approx ((\text{Direct Output} + \text{Indirect Output} + \text{Induced Output})_{HH} + (\text{IBT/Output} * \text{LG Spending/IBT} * \text{Total Output/LG Spending})) / \text{Direct Output}$$

Term 6, "Total Output/LG Spending," is a response coefficient. Response coefficients are impacts analyzed in IMPLAN on a "per unit" basis. The unit can be in physical terms, such as "thousand recreation visits, or in monetary terms, such a $1,000,000. In this methodology, $1,000,000 is applied to a spending pattern representative of local governments to establish a response coefficient per dollar of local government spending. The key component of this response coefficient is ascertaining a representative spending pattern. The mix of goods and services purchased by local governments is not readily available from local government accounting systems. Such systems are structured to meet fiscal reporting requirements, not economic analysis requirements. The Bureau of Economic Analysis develops a national spending pattern for state and local general governments as part of its work on the national benchmark input-output model.[22] IMPLAN draws from this work and provides a national spending pattern as a part of its modeling system.[23] In both the customized models and the approximation methodology, the pattern in IMPLAN was considered as representative of local government spending behavior. The mix includes all goods and services, including government labor. The spending pattern for general government in IMPLAN is distinct from the spending pattern for education functions and capital investments.

A simple Excel worksheet was developed to 1) compute total output throughout the economy generated by local government spending made possible by tax payments associated with every dollar of production by the given industry and then 2) add the results to the original output multiplier.

A comparison of results is discussed in the Findings section of this report.

Local Governments in Otero, Pueblo, and Summit Counties

As of January 30, 2011, there were 3,322 local governments within the state of Colorado.[24] There were 64 counties and 269 municipalities of various kinds. After accounting for 178 elementary and secondary school districts, there are 2,811 special districts and authorities in Colorado.

In the latest directory of local governments, the Colorado Department of Local Affairs identified 101 non-educational local governments with jurisdiction in Otero, Pueblo, and Summit Counties.[25] Of this number, several entities

[22] Bureau of Economic Analysis, Department of Commerce. 2008. 2002 Standard Make and Use Tables at the Detailed Level. http://www.bea.gov/industry/io_benchmark.htm#2002data on January 26, 2011.

[23] MIG, Inc. 2004. IMPLAN Professional Version 2.0 User's, Analysis, and Data Guide. p. 261.

[24] Colorado Department of Local Affairs, Division of Local Government. 2011.

[25] Colorado Department of Local Affairs, Division of Local Government. 2010. County, Municipality, and Special District Mailing List. Denver, CO.

were omitted from the study for the following reasons:

- Arkansas River Power Authority (based in Lamar and serving six communities across southeastern Colorado, including La Junta, but no operations in Otero County)
- Colorado River Water Conservancy District (covering 15 counties, but with no staff or operations in Summit County)
- Eight conservation districts (all districts are either exceptionally small with revenues of less than $35,000 in 2007 or without staff or operations in the three test counties)
- A variety of special districts that: are no longer in existence, are exceptionally small, have operations located primarily outside the test counties, or for which financial data could not be obtained (20 special districts)

Two local governments, Breckenridge Sanitation District and the Board of Water Works of Pueblo, CO, were not separately listed in the Colorado Department of Local Affairs directory, but included in the study.

In sum, the financial data for 73 local governments were included in the customization of the three IMPLAN models. These are shown in Table 2.

As noted in the previous section, government enterprises are treated as distinct industries in the IMPLAN system. Two kinds of enterprises were modeled: passenger transit in Pueblo County and water and sewer services in all three counties. Table 3 lists the enterprise activities from general governments that were modeled as enterprise industries in the customized models.

Financial documents were sought for all local governments and local government enterprises in the study area. Essential documents for an entity are the Comprehensive Annual Financial Report (CAFR) for 2007 and the adopted budget for 2009, the latter because it reports "actual" revenue and expenditure data for 2007 and usually contains total payroll cost data that may be missing from the CAFR.

Central sources used to collect financial documents in electronic form or on paper included the Colorado Office of the State Auditor for the CAFR and the Division of Local Government of the Colorado Department of Local Affairs (DOLA) for budgets. Some data were obtained from summaries of CAFR information that DOLA posts on line for a number of local entities.[26] Because of gaps in the central records, some documents and, in some cases specific data items, were obtained directly from the entity itself. These documents were downloaded from an entity's web site, when available, or personally requested by phone or email.

Employment for all local governments was obtained by special request from the Department of Local Affairs, State Demography Office.

[26] These data are accessible via the "Local Financial Information" feature of DOLA's web site (http://dola.colorado.gov/dlg/resources/financial_compendium/lgov_fin_a.html).

Table 2. Local governments Included in the Customization of IMPLAN Models.

Type of Government	Otero	Pueblo	Summit
County	Otero County	Pueblo County	Summit County
Municipality	Cheraw, Town of Fowler, Town of La Junta, City of Manzanola, Town of Rocky Ford, City of Swink, Town of	Boone, Town of Pueblo, City of Rye, Town of	Blue River, Town of Breckenridge, Town of Dillon, Town of Frisco, Town of Montezuma, Town of Silverthorne, Town of
Special Districts *Water/Sanitation*	North La Junta Sanitation District	Avondale Water & Sanitation District Beulah Water Works District Blende Sanitation District Pine Drive Water District Salt Creek Sanitation District St. Charles Mesa Sanitation District St. Charles Mesa Water District	Alpensee Water District Breckenridge Sanitation District East Dillon Water District Frisco Sanitation District Mesa Cortina Water & San District Snake River Water District
Special Districts *Fire Protection*	Fowler Rural FPD La Junta Rural FPD Manzanola Rural FPD Rocky Ford Rural FPD	Pueblo Rural FPD Rye FPD West Park FPD	Lake Dillon FPD Lower Blue FPD Red, White & Blue FPD Summit County FPD
Special Districts *Other*	Fowler Housing Authority La Junta Housing Authority La Junta Urban Renewal Authority Lower Ark. Valley Water Cons. Dist. Otero County Housing Authority Rocky Ford Housing Authority	Bandera Boulevard Spec Impr Maint District Colorado City Cemetery District Colorado City Metropolitan District Pueblo West Metropolitan District Historic Arkansas Riverwalk Of Pueblo Pueblo City-County Library District Pueblo Depot Activity Develop Authority Housing Authority of the City of Pueblo Southpointe Special Improv Maint District S.E. Colorado Water Conservancy District	Alpine Metropolitan District Breckenridge Mtn Metro. District Buffalo Mountain Metro District Copper Mtn Consol. Metro District Corinthian Hill Metro District Dillon Valley Metro District Eagles Nest Metro District Hamilton Creek Metro District Summit County Housing Authority Swan's Nest Metropolitan District Willow Brook Metropolitan District

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Table 3. Enterprises Extracted from Local Governments in the Customization of IMPLAN Models.

	County		
Enterprise Purpose	Otero	Pueblo	Summit
Water & Sewer Services	Town of Swink Town of Cheraw Town of Fowler City of La Junta Town of Manzanola Town of Rocky Ford	Town of Boone Colorado City Metropolitan District City of Pueblo Pueblo West Metropolitan District Town of Rye	Summit County-Snake River Sewer Town of Breckenridge Buffalo Mountain Metropolitan District Copper Mtn Consol Metro District Town of Dillon Dillon Valley Metropolitan District Town of Frisco Town of Silverthorne Willow Brook Metropolitan District
Passenger Transit		City of Pueblo	

Findings

Tables 4 through 6 show the changes in output multipliers for 17 industry groups[27] in the three test counties that occur when the closure and approximation approaches are applied. The first three columns are derived from the customized model, and the last three columns are derived from the default model with the approximation methodology. In each set of columns, traditional multipliers are shown first, multipliers with local governments included are shown second, and the percent increase from the first to the second multiplier is shown last. As noted earlier, only general government operational spending is considered in both the customized model and the approximation technique. Education and investment spending of local governments is excluded.

The upper portion of each table provides results for 17 industry groups. The pattern of multiplier increases among industry groups was similar across the test counties. The largest increases were found in Wholesale & Retail Trade, Real Estate & Rental, and in Utilities. The smallest increases were found in Construction, Manufacturing, Private Educational Services, and Health & Social Services. These differences are consistent with the share of total outlays paid as indirect business taxes. Those industry groups with the largest shares responded with the largest increases, and those with the smallest shares increased the least. As discussed earlier, indirect business taxes are the primary source of local government revenues, and therefore support a large share of local government spending. Table A-1 in the Appendix provides a list of industries in the United States that pay the largest share of their outlays to indirect business taxes.

[27] The industry structure is comparable to 2-digit NAICS industries.

Some industries with large payments to indirect business taxes are also major providers of goods and services to government operations and households. Leased space, equipment rental, wholesaler purchases, and electric utilities are major components of government expenditures. Home ownership, rent, electric utilities, and retail purchases are major expenditures by households receiving income from government payrolls. Thus, the inclusion of government operational spending in the induced component of output multipliers affects certain industries far more than other industries.

The lower portion of each table provides the mean, weighted mean, maximum, minimum, and standard deviation of multipliers for each county. The weighted mean (based on industry final demands) recognizes that some industries have substantially more influence in the region's economy than others. Standard deviation is presented to summarize the variability of multipliers across the economy.

Overall, none of the multipliers changed dramatically when local government operations were included in the multiplier matrix of the customized models. Otero County showed the smallest increases, Pueblo County somewhat larger increases, and Summit County the largest changes. Unweighted average multipliers increased by 1.4 percent in Otero, 2.0 percent in Otero, and 3.3 percent in Summit.

The greater increase in Summit can be explained by a large tourism industry. Because Summit County is an internationally-recognized resort destination, local government operations provide services to not only local residents, but also a large visitor population. A large source of revenues for these services is indirect business taxes paid by tourism-related sectors – e.g. retail trade, auto rental, and lodging. These same sectors are among the largest payers of indirect business taxes per dollar of sales (see Table A-11). Consequently, when combining the magnitude of tourism-related sectors with high payments of indirect business taxes and sizable government spending, the added induced effect to multipliers becomes notable. Table 7 shows the individual industries whose multiplier was most affected in Summit County by adding local government spending to the induced effect.

The approximation methodology *overestimated* multiplier increases by about two-to-one in Otero County and about 1.5-to-one in Pueblo County compared with the customized models. In Summit County, the approximation *underestimated* the increase by about one quarter. Consequently, these results did not provide a reliable estimate of the magnitude of multiplier increases compared with the customized models. However, the results did exhibit the same relative increase in multipliers across industry groups as found in the customized models. For example, Wholesale and Retail Trade multipliers increased the most, Manufacturing increased the least, and the changes relative to each other were similar, regardless of method.

These results suggest that the approximation technique offers a weak guide to the absolute increase of multipliers compared with customized models, but offers a dependable guide to the relative increase of multipliers when industry groups are compared among each other. This consistent relationship among industry groups is likely a reflection of the government spending pattern provided by IMPLAN which is used in both the customized model and the approximation methodology.

Weighted means are provided in each table to recognize that some industries are relatively more important than others in a regional economy. While the mean multiplier treats each industry equally, the weighted mean gives more emphasis to those that are influential. Because sales to final demand drive a regional economy, these were used as the weighting basis. The weighted mean was somewhat less than the simple mean in both Otero County and Pueblo Counties, and about 33 percent larger in Summit County. A larger weighted mean in Summit County is expected given the larger multipliers associated with the tourism-oriented industry groups of Wholesale & Retail Trade, Accommodations & Food Services, and Real Estate & Rental.

Multipliers have been calculated for three other measures of economic activity. Employment, labor income (also called earnings), and value added (also called gross regional product) multipliers for each of the test counties are available upon request. While they vary somewhat from the output multipliers in Tables 4 through 6, the magnitude and patterns are similar. Where magnitudes and patterns differ from the output multipliers, they can be traced to the strong influence of Real Estate and Rental, Electric Power, and Wholesale Trade in the industry group supply chain for generating additional local government revenues and subsequent spending.

Table 4. Output Multipliers Closed for Households & Local Governments, Statistical Summary, Otero County, CO 2007.

Description	N	Customized IMPLAN Model			Default IMPLAN Model with Approximation Methodology		
		Multiplier (HH only Endogenous)	Multiplier (HH & Local Govt Endogenous)	Percent Increase	Multiplier (HH only Endogenous)	Multiplier (HH & Local Govt Endogenous)	Percent Increase
Mean for Industry Groups							
Agriculture	11	1.254	1.266	1.0%	1.254	1.280	2.1%
Mining	---	-	-	-	---	---	---
Utilities	3	1.203	1.227	1.9%	1.206	1.257	4.2%
Construction	7	1.335	1.345	0.7%	1.336	1.355	1.4%
Manufacturing	14	1.303	1.309	0.5%	1.304	1.316	1.0%
Wholesale & Retail Trade	13	1.358	1.406	3.6%	1.359	1.465	7.8%
Transportation & Warehousing	6	1.368	1.387	1.4%	1.370	1.408	2.8%
Information	4	1.257	1.269	0.9%	1.258	1.282	1.9%
Finance & Insurance	5	1.590	1.601	0.7%	1.591	1.614	1.5%
Real Estate & Rental	5	1.322	1.354	2.4%	1.323	1.391	5.2%
Professional Services	9	1.418	1.429	0.8%	1.419	1.442	1.6%
Administrative & Waste Services	6	1.385	1.401	1.2%	1.387	1.411	1.7%
Educational Services	1	1.375	1.384	0.6%	1.376	1.393	1.2%
Health & Social Services	8	1.379	1.389	0.7%	1.380	1.398	1.3%
Arts, Entertainment, & Rec Services	5	1.365	1.386	1.5%	1.367	1.410	3.2%
Accommodation & Food Services	3	1.389	1.412	1.6%	1.392	1.437	3.2%
Other Services	12	1.386	1.404	1.3%	1.387	1.423	2.5%
Statistics across All Industries							
Mean	112	1.353	1.371	1.4%	1.354	1.392	2.8%
Weighted Mean (re: final demand)	112	1.339	1.352	0.9%	1.343	1.369	1.9%
Maximum	112	1.845	1.858	0.7%	1.846	1.874	1.5%
Minimum	112	1.089	1.103	1.2%	1.090	1.120	2.7%
Standard Deviation	112	0.108	0.108	0.7%	0.108	0.111	2.9%

Because government sectors were restructured in the customized model, comparisons across models are not valid. Therefore, government sectors are excluded from this table.

Maximum, Minimum, and Standard Deviation refer to observations of multiplier values and of "Percent Difference", respectively, among all industries.

Table 5. Output Multipliers Closed for Households & Local Governments, Statistical Summary, Pueblo County, CO 2007.

Description	N	Customized IMPLAN Model			Default IMPLAN Model with Approximation Methodology		
		Multiplier (HH only Endogenous)	Multiplier (HH & Local Govt Endogenous)	Percent Increase	Multiplier (HH only Endogenous)	Multiplier (HH & Local Govt Endogenous)	Percent Increase
Mean for Industry Groups							
Agriculture	11	1.244	1.265	1.7%	1.244	1.279	2.8%
Mining	4	1.389	1.417	2.0%	1.392	1.434	3.1%
Utilities	3	1.274	1.317	3.4%	1.279	1.346	5.3%
Construction	7	1.432	1.452	1.4%	1.433	1.462	2.0%
Manufacturing	63	1.314	1.327	1.0%	1.316	1.335	1.5%
Wholesale & Retail Trade	13	1.450	1.547	6.7%	1.452	1.596	9.9%
Transportation & Warehousing	7	1.469	1.501	2.1%	1.473	1.519	3.1%
Information	10	1.439	1.458	1.4%	1.442	1.472	2.1%
Finance & Insurance	6	1.587	1.608	1.3%	1.590	1.622	2.0%
Real Estate & Rental	7	1.387	1.438	3.7%	1.390	1.469	5.7%
Professional Services	13	1.537	1.560	1.5%	1.542	1.576	2.2%
Administrative & Waste Services	9	1.523	1.546	1.5%	1.527	1.561	2.2%
Educational Services	3	1.550	1.573	1.5%	1.552	1.585	2.1%
Health & Social Services	8	1.506	1.527	1.4%	1.508	1.538	2.0%
Arts, Entertainment, & Rec Services	9	1.564	1.604	2.5%	1.575	1.634	3.8%
Accommodation & Food Services	3	1.479	1.520	2.8%	1.482	1.544	4.2%
Other Services	13	1.489	1.524	2.3%	1.492	1.543	3.4%
Statistics across All Industries							
Mean	189	1.412	1.440	2.0%	1.415	1.457	2.9%
Weighted Mean (re: final demand)	189	1.405	1.427	1.6%	1.406	1.439	2.4%
Maximum	189	1.839	1.872	1.8%	1.842	1.891	2.7%
Minimum	189	1.103	1.119	1.5%	1.103	1.124	1.8%
Standard Deviation	189	0.137	0.144	5.0%	0.139	0.149	7.3%

Because government sectors were restructured in the customized model, comparisons across models are not valid. Therefore, government sectors are excluded from this table.

Maximum, Minimum, and Standard Deviation refer to observations of multiplier values and of "Percent Difference", respectively, among all industries.

le of Contents

Table 6. Output Multipliers Closed for Households & Local Governments, Statistical Summary, Summit County, CO 2007.

Description	N	Customized IMPLAN Model			Default IMPLAN Model with Approximation Methodology		
		Multiplier (HH only Endogenous)	Multiplier (HH & Local Govt Endogenous)	Percent Increase	Multiplier (HH only Endogenous)	Multiplier (HH & Local Govt Endogenous)	Percent Increase
Mean for Industry Groups							
Agriculture	5	1.290	1.332	3.2%	1.300	1.333	2.5%
Mining	4	1.430	1.462	2.3%	1.450	1.475	1.7%
Utilities	2	1.341	1.409	5.1%	1.372	1.427	4.0%
Construction	7	1.432	1.459	1.9%	1.447	1.467	1.4%
Manufacturing	16	1.313	1.333	1.5%	1.327	1.342	1.1%
Wholesale & Retail Trade	13	1.426	1.549	8.6%	1.443	1.541	6.8%
Transportation & Warehousing	7	1.443	1.483	2.8%	1.464	1.496	2.1%
Information	10	1.455	1.485	2.1%	1.472	1.495	1.6%
Finance & Insurance	5	1.591	1.625	2.1%	1.612	1.638	1.6%
Real Estate & Rental	7	1.401	1.467	4.8%	1.416	1.469	3.8%
Professional Services	14	1.556	1.590	2.2%	1.580	1.605	1.6%
Administrative & Waste Services	9	1.509	1.544	2.4%	1.534	1.560	1.7%
Educational Services	1	1.551	1.581	1.9%	1.575	1.597	1.4%
Health & Social Services	7	1.506	1.538	2.1%	1.528	1.551	1.5%
Arts, Entertainment, & Rec Services	8	1.488	1.546	3.9%	1.512	1.557	3.0%
Accommodation & Food Services	3	1.453	1.515	4.3%	1.476	1.524	3.3%
Other Services	10	1.470	1.522	3.5%	1.491	1.530	2.7%
Statistics across All Industries							
Mean	129	1.447	1.495	3.3%	1.467	1.503	2.5%
Weighted Mean (re: final demand)	129	1.391	1.453	4.4%	1.407	1.456	3.5%
Maximum	129	1.736	1.775	2.3%	1.769	1.798	1.6%
Minimum	129	1.106	1.156	4.5%	1.109	1.149	3.6%
Standard Deviation	129	0.119	0.122	2.2%	0.124	0.125	0.8%

Because government sectors were restructured in the customized model, comparisons across models are not valid. Therefore, government sectors are excluded from this table.

Maximum, Minimum, and Standard Deviation refer to observations of multiplier values and of "Percent Difference", respectively, among all industries.

Table 7. Top 20 Industries with the Largest Increase in Multiplier, Summit County, CO 2007.

	Customized IMPLAN Model			Default IMPLAN Model with Approximation Methodology		
Description	Multiplier (HH only En-dogenous)	Multiplier (HH & Local Govt Endogenous)	Percent Increase	Multiplier (HH only En-dogenous)	Multiplier (HH & Local Govt Endoge-nous)	Percent Increase
Retail Stores - Furniture and home furnishings	1.418	1.546	9.0%	1.434	1.536	7.1%
Retail Stores - Gasoline stations	1.373	1.496	9.0%	1.388	1.487	7.1%
Retail Stores - General merchandise	1.444	1.573	9.0%	1.462	1.565	7.0%
Retail Stores - Clothing & clothing accessories	1.385	1.507	8.8%	1.400	1.497	7.0%
Retail Stores - Food and beverage	1.451	1.578	8.8%	1.469	1.571	6.9%
Retail Stores – Sport'g goods/hobby/book/music	1.434	1.560	8.8%	1.452	1.552	6.9%
Retail Stores - Building materials/garden supply	1.419	1.544	8.8%	1.435	1.535	6.9%
Retail Stores – Miscellaneous	1.450	1.574	8.6%	1.467	1.566	6.8%
Retail Stores - Motor vehicle and parts	1.476	1.601	8.4%	1.496	1.594	6.6%
Retail Nonstores - Direct and electronic sales	1.312	1.421	8.3%	1.321	1.409	6.6%
Retail Stores - Health and personal care	1.476	1.599	8.3%	1.495	1.593	6.5%
Wholesale trade businesses	1.400	1.513	8.0%	1.417	1.507	6.3%
Retail Stores - Electronics and appliances	1.505	1.626	8.0%	1.524	1.621	6.3%
Real estate establishments	1.250	1.346	7.7%	1.261	1.337	6.0%
Electric power generation/transmission/distrib.	1.198	1.285	7.3%	1.212	1.282	5.8%
Imputed rental for owner-occupied dwellings	1.293	1.377	6.5%	1.298	1.366	5.3%
Amusement parks, arcades, & gambling	1.382	1.465	6.0%	1.401	1.467	4.7%
Hotels and motels, including casino hotels	1.431	1.513	5.7%	1.453	1.517	4.4%
Automotive repair & maintenance	1.396	1.473	5.5%	1.412	1.472	4.3%
Automotive equipment rental & leasing	1.473	1.552	5.4%	1.494	1.557	4.2%

Conclusion

Economic multipliers are used by Federal, state, and local governments to estimate the total regional effects of direct changes in production by private industry. Resource management decisions, economic development initiatives, and government regulation are examples of actions where economic multipliers have been used for impact analysis.

Practitioners who use multipliers often ask about the scope of the economic effects that are included in their results. The scope of direct (initial) and indirect (supply-chain) effects is well-established and generally understood. On the other hand, the scope of induced effects (the endogenous effect of regional household, government and other "institution" spending) is open for discussion. By current convention, the induced effect is specified as household spending triggered by labor income from local industries. This study has considered the merits of whether to extend the induced effect to include capital investment and local government (non-education) operations.

Capital investment has long been a topic of discussion in regional economic circles, with a clear consensus that it is not appropriate for inclusion in the induced component of an I-O model and the multipliers that result. Local government operations, however, are well-connected to regional business activity and therefore are an excellent candidate for inclusion in the induced component of multipliers.

Using primary data from financial documents of three Colorado counties, the IMPLAN modeling system was used to examine the inclusion of spending by local government operations in a variety of multipliers. The results showed that across all counties, multipliers increased on average from one to three percent over their conventional specification. This suggests that including local government operations in the induced component generally does not appreciably change multipliers readily available from modeling systems, such as IMPLAN.

A closer inspection of industry groups revealed that multipliers for Wholesale and Retail Trade, Real Estate and Rental, and Utilities differed from the average by showing substantially larger increases than other sectors. While this pattern was true for all three counties, the largest increase was observed in Summit County where Wholesale and Retail Trade was boosted by 8.5 percent when local government spending was included in the induced effect.

The reason for larger increases rests with a considerable tourism industry. Because Summit County is an internationally-recognized resort destination, local government operations provide services to not only local residents, but also a large visitor population. A large source of revenues for these services is indirect business taxes paid by tourism-related sectors – e.g. retail trade, auto rental, and lodging. These same sectors are among the largest payers of indirect business taxes per dollar of sales. Consequently, when combining the magnitude of tourism-related sectors with high payments of indirect business taxes and sizable government spending, the added induced effect to multipliers becomes noteworthy. Under these conditions, multipliers that only account for household spending are likely to understate the induced effect for tourism-based industries.

When modeling events or policies that focus on tourism-based industries in tourism-based economies, a practitioner may wish to consider the inclusion of local government operations in the induced effect. If this is done, clear definitions are essential. Under these circumstances, the presentation of multipliers both with and without local government operations spending is advised.

The approximation methodology examined in this study did not yield results that could substitute for a complete model customization. However, the methodology is inexpensive and offers a relative indicator of industry linkages with local government operations. It may offer a suitable, albeit rough, approximation of multipliers for tourism-based industries where local government operation spending is included in the induced effect.

Finally, two recommendations are offered for future research. First, a better understanding of linkages between local business activity and local school district operations is needed. Reliance of local schools on state funding is often quite high and was the basis for excluding school district operations in this study. Nonetheless, the relationship between state and local funding can vary substantially among districts. An in-depth examination of that variance and its linkages with local business activity and assets would offer useful insights to community leaders. Second, more accurate methods for approximating the induced effect with local government spending should be sought. An inexpensive yet accurate methodology may be especially valuable for community leaders and analysts of tourism economies.

Appendix

Table A-1. Indirect Business Taxes (IBT) as a Share of Total Outlays, Top 30 Industries, United States 2007.

Rank	Industry Code	Industry Description	Common Tourism Industries	IBT as a Percent of Outlays
1	73	Distilleries		46.3%
2	71	Breweries		16.0%
3	322	Retail Stores - Electronics and appliances		15.7%
4	321	Retail Stores - Furniture and home furnishings		15.6%
5	329	Retail Stores - General merchandise	X	15.6%
6	328	Retail Stores - Sporting goods, hobby, book and music	X	15.5%
7	323	Retail Stores - Building material and garden supply		15.5%
8	326	Retail Stores - Gasoline stations	X	15.5%
9	331	Retail Nonstores - Direct and electronic sales		15.4%
10	325	Retail Stores - Health and personal care		15.4%
11	327	Retail Stores - Clothing and clothing accessories	X	15.4%
12	324	Retail Stores - Food and beverage	X	15.3%
13	330	Retail Stores - Miscellaneous	X	15.2%
14	320	Retail Stores - Motor vehicle and parts		15.1%
15	74	Tobacco product manufacturing		14.8%
16	319	Wholesale trade businesses	X	14.3%
17	360	Real estate establishments	X	12.3%
18	31	Electric power generation, transmission, and distribution		11.9%
19	361	Imputed rental activity for owner-occupied dwellings		11.0%
20	409	Amusement parks, arcades, and gambling industries	X	10.1%
21	21	Mining coal		9.7%
22	411	Hotels and motels, including casino hotels	X	9.0%
23	338	Scenic and sightseeing transportation and support activities for transportation	X	8.4%
24	364	Video tape and disc rental		8.4%
25	351	Telecommunications		7.8%
26	414	Automotive repair and maintenance, except car washes		7.7%
27	362	Automotive equipment rental and leasing	X	7.6%
28	23	Mining copper, nickel, lead, and zinc		7.5%
29	18	Commercial hunting and trapping		7.3%
30	408	Bowling centers		7.3%

Source: MIG, Inc.

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The Effect of Oil Revenue on Consumption Expenditure in Iran

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Abstract. With the current debate about putting restrictions on Iran's oil revenue, little is understood about how this will affect the welfare of people in Iran. Therefore, in this study the effect of oil revenue on consumption expenditure in Iran has been studied. In order to do so, data regarding the national accounts of Iran as well as other relevant variables are gathered. Different models are developed and tested and although it was expected to find a significant and positive relationship between the oil revenue and consumption expenditure, results do not support this hypothesis. The findings of this paper suggest that oil export restrictions will not have a strong detrimental effect on Iranian's consumption. However the data is not sufficient to reject the hypothesis that a complete sanction would not have a harmful effect.

Keywords: Oil revenue, Consumption expenditure, Iran, Sanction, Welfare, Simultaneous equations

Introduction

Oil revenue has a major impact on the oil exporters in both developed and developing countries.[1] Moreover many of developing countries which are considered as oil exporters are also considered as oil dependent economies. This means that any fluctuation in oil revenue has different important effects on these countries. Therefore a sudden decrease in oil revenue as a result of a restriction or sanction can be very harmful and detrimental for the government as well as people who live in such countries. Thus, it is important to study the effect of punishment measures like oil sanctions on different dimensions of these economies.

The effect of oil revenue on economy of oil exporters has been studied several times and from different points of view. Most of these views shared one point: Government expenditure. Although they defined deferent macro-level questions but when they decided to answer these questions, they studied the effect of change in oil revenue on government expenditures and by using this analysis, they answered their research questions. This approach becomes insufficient when it leads to some general policy implications.

As an example, here I quoted a policy implication which is discussed in a recent study by Farzanegan (2011):

> *"The policy implications of these results are straightforward. Those sanctions aiming to restrict the Iranian government's oil export capacities and consequently oil export revenues may affect the military spending of Iran and not the social, education, and health efforts. Unexpected shocks in negative changes of oil rents even force the Iranian state to expand the non-oil economy, investing more in education and health sectors."*

Such policy implications need to be accompanied by a review on the other side of the story, i.e. how can this sanction affect people's life

[1] Oil revenue refers to oil industry export revenue which includes both oil and gas export revenue, excluding any petrochemical revenue.

in Iran? To address this question, I diverge from the previous literature by analyzing how changes in oil revenue affect private consumption instead of government expenditure using Iranian data. Oil revenue is the main source of income in a developing country like Iran and its fluctuation must affect people's life. So while previous studies find sanctions on Iran's oil as a good policy to restrict its military plans, this paper tries to examine the effect of this policy on the other side of the story: private consumption.

If consumption per capita can be defined as a measure of welfare, then the effect of oil revenue fluctuations on this index can be viewed as people's dependency on oil revenue. A strong relationship between oil revenue and private consumption would suggest a need to find other approaches to avoid hurting Iranian citizens.

The remaining part of paper is organized as follows: in section 2, previous works about the impact of oil revenue and its fluctuations on oil exporting countries is briefly examined. Then, the data which is used in this study is introduced in section 3. In section 4, the methodology and models of this paper are explained. Results of the regression analysis are presented in section 5 which are accompanied by the results of the sensitivity analysis. Finally, conclusion, and policy implications of this study are provided in section 6.

Literature Review

Many researchers have studied the economics of countries with abundant natural resources. The main stream of these efforts focuses on the so-called "resource curse" phenomenon. Natural resource curse is defined as "A paradoxical situation in which countries with an abundance of non-renewable resources experience stagnant growth or even economic contraction" (Investopedia). Different reasons for this phenomenon have been suggested in the literature including "long-term trends in world commodity prices, volatility, crowding out of manufacturing, civil war, poor institutions, and the Dutch Disease" (Frankel, 2010). Although a rival point of view exists which does not accept the natural resource curse and views it as a blessing (Esfahani, 2009), the majority of research has shown the existence of this problem in resource-rich countries.

The last reason mentioned above, the Dutch Disease, refers to the situation in which a government increases its expenditure due to a temporary increase in the commodity price in the world (Frankel (2010)). Frankel (2010) discusses the consequences of this behavior and points out two main results: inflation and current account deficit.

Both of these consequences would not happen if the private consumption has remained unchanged. The excess expenditure by government would increase the money available to its people which would result in more demand for both domestic and imported goods. The effect is strong enough to affect the economy as a whole and is described as a "disease." The effect of fluctuation in natural-resource export revenue on the private consumption has not been studied yet although the effect of such increase in revenue on the government expenditures has been addressed in several studies generally and for oil exporters in particular.

Metwally (2000) studied the Golf Cooperation Council's countries and found that in most cases there is a strong relationship between the boom in oil exports and the government expenditures in these countries. This is in line with the findings of Mashayekhi (1998) which compared four oil exporter countries and has found similar results.

In past ten years several empirical studies has been done regarding the macroeconomic effects of oil in both developed and developing countries. Farzanegan (2011) has summarized the results of these studies. For developed countries, the effect of oil price shocks on government expenditure and stock market has been studied. Additionally, empirical studies about the developing countries have addressed issues like tax, inflation and output, as well as the government expenditure (Farzanegan (2011)). The positive relationship which is shown that exists between the oil revenue and the outputs of a country (Farzanegan (2011)) is particularly related to this study. This increased quantity of goods and services (resulted from increase in output and current account deficit) must have been consumed by the private sector of these countries which increases the validity of the belief in the direct relationship between the oil revenue and private consumption in oil-exporting countries. To the best of my knowledge, this relationship has not been addressed in the previous literature. Therefore it is valuable to study the effect of oil revenue on private consumption to find evidence for the theory which is developed above.

Data

In order to study the effect of oil revenue on private consumption in Iran, national account data of this country was obtained from the central bank of Iran's website (CBI). The available data on this website covers the years from 1960 to 2007. Moreover, the data regarding the population of Iran and its consumer price Index (CPI) was obtained from the World Bank website (WB). Finally the other piece of data which is needed for this study is the real exchange rate which was obtained from Economic Research Service, U.S. Department of Agriculture (ERS). 1970 is the earliest year which this data set has available data for it. Table 1 defines variables which are used in this study.

Table1: Variables used in this study and their definition

Variable	Definition
ORPC	Oil revenue per capita
CEPC	Consumption expenditure per capita
GEPC	Government expenditure per capita
IPC	Investment per capita
OEPC	Other export per capita (It is calculated by dividing the amount of export (excluding oil) by the number of population)
IMPC	Import per capita
NTPC	Net Tax per capita (It is calculated by dividing the amount of net tax (tax minus transfer payment) by the number of population)
NIPC	National income per capita (This variable is calculated according to EQ.3)
NOIPC	Non-oil Income per capita: (This variable is calculated according to EQ.4)
NODPC	Non-oil disposable income per capita: It is equal to NIPC minus NTPC
DIPC	Disposable income per capita: it is equal to NODPC plus ORPC

D1	Dummy variable for revolution in Iran (years after 1979): Zero for years before revolution and one for years after revolution.
D2	Dummy variable for Iran-Iraq war (1980-1988): Zero for years of peace and one for years of war.
q	Real exchange rate (This variable is obtained from ERS)
INF	Inflation rate: Calculated by Using Consumer Price Index (CPI): $\frac{CPI_t - CPI_{t-1}}{CPI_{t-1}}$

Figure 1 is shown two main parameters of this study over time: oil revenue per capita (ORPC) and consumption expenditure per capita (CEPC). It should be noted that values for CEPC and ORPC are shown in constant prices of 1997/98. According to Figure 1, in the initial years, there is a close relationship between these variables' behavior. Around 1975, this relationship is changed: CEPC remains unchanged while ORPC dropps dramatically. But around 1980 again changes in CEPC seems to be in line with changes in ORPC. However, from 1980 until 1995, these two variables remain almost constant. Around 1995, CEPC starts to rise and around 2000 this increase becomes sharper while there is no change in ORPC. Initial explanation would be that the consumption expenditure was closely related to the oil revenue in the initial years but this relationship has lost its importance at least over the last decade. However this relationship needs more examination.

Figure 1. Amount of CEPC and ORPC in Iranian Rial (million) for different years in constant prices

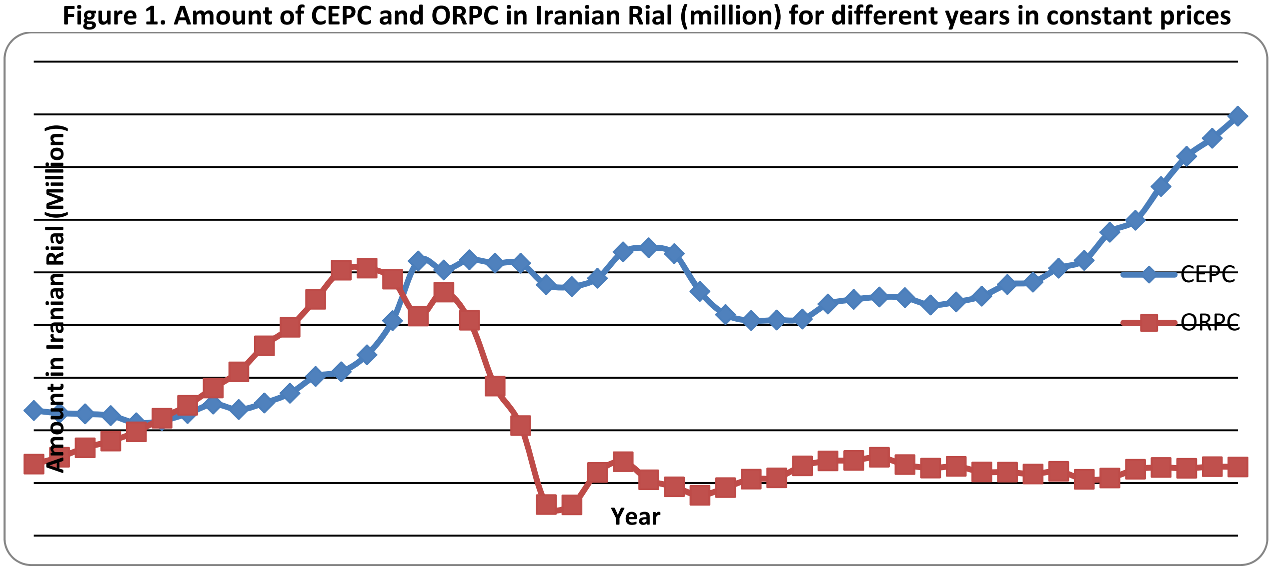

Table 2 shows the summary statistics of the main variables of this study. It should be noted that all variables are in constant prices (1997/98). According to this table, a simple comparison between ORPC and OEPC reveals how important oil exports are for Iran comparing to other exports. Another interesting variable is NTPC which according to the table, it is obvious that tax revenue is not an important source of government income throughout 48 years time span of this study. This fact also uncover the other important truth about Iran's government which in absence of sufficient tax revenue, it depends mainly on other sources of revenue which oil revenue is the main one.

Table 2. Summary statistics of the important variables in constant prices (Billion Rials)

Variable	Obs.	Minimum	Maximum	Mean	Standard Deviation
CEPC	48	1.07	3.98	2.18	0.72
GEPC	48	0.18	1.65	0.74	0.37
IPC	48	0.56	3.97	1.74	0.78
IMPC	48	0.32	3.84	1.25	0.82
ORPC	48	0.29	2.54	1.00	0.66
OEPC	48	0.02	0.47	0.19	0.14
NTPC	48	-0.11	0.32	0.11	0.1
NOIPC	48	1.58	6.41	3.59	1.2
NODPC	48	1.45	6.43	3.48	1.26

Methodology

Modeling Approach

According to the table 1, all of the variables can be calculated by using the data described above. To better understand how these variables are related, there is a need for further explanation which is presented below. Starting from the national income identity:

$$(EQ.1) \quad Y = C + G + I + EX - IM$$

"Y" is the national income, "C" is the private consumption, "G" is the government expenditure, "I" is the amount of investment, "EX" is the amount of Export and "IM" is the amount of import. If we divide the exports between two types of "Oil Exports/ Oil Revenue (OR)" and "Non-oil/Other Exports (OE)" then we have:

$$(EQ.2) \quad Y = C + G + I + OR + OE - IM$$

Now by dividing both sides of the equation by the number of population we have:

$$(EQ.3) \quad NIPC = CEPC + GEPC + IPC + ORPC + OEPC - IMPC$$

If we define "Non-oil income per capita (NOIPC)" as:

$$(EQ.4) \quad NOIPC = CEPC + GEPC + IPC + OEPC - IMPC$$

Then we can rewrite EQ.3 as:

$$(EQ.5) \quad NIPC = NOIPC + ORPC$$

Now, if we define "Net tax (NT)" as:

$$(EQ.6) \quad NT = Tax - Transfer\ Peyment$$

The "Net tax per capita (NTPC)" would be:

$$(EQ.7) \quad NTPC = \frac{NT}{Population}$$

Finally disposable income per capita (DIPC) can be calculated as:

$$(EQ.8) \quad DIPC = NOIPC - NTPC + ORPC$$

Which is equal to:

$$(EQ.9) \quad DIPC = NODPC + ORPC$$

Here, the net tax is deducted from the non-oil income per capita and it defined a new variable, "Non-oil disposable income per capita (NODPC)," simply because the net tax which is reported in Iran's national accounts does not consider the tax on oil revenue.

The tax on oil revenue is a young policy topic in Iran. Historically, the oil is sold by the government and since the whole revenue is received by it, it was seen no need to tax its revenue. With new public policy approach by Iran's government which taxes oil revenue, it still does not have a clear process and government agencies do not report the tax revenue from oil. Therefore, because of lack of data on how oil revenue is taxed recently in Iran, it is considered untaxed in this study. Thus, the total disposable income per capita can be calculated according to EQ.9.

Econometric Models

Using Keynesian consumption function is the first step. This function has been shown in EQ.10 and then it is rewritten in EQ.11 using the analogy introduced in this paper.

$$(EQ.10) \quad C = \alpha_0 + \alpha_1 YD + \alpha_2 D1 + \alpha_3 D2 + \varepsilon$$
$$(EQ.11) \quad CEPC = \alpha_0 + \alpha_1 NDIPC + \alpha_2 D1 + \alpha_3 D2 + \varepsilon$$

It must be noted that "C" is consumption, "YD" is disposable income and ε is the error term (D1 and D2 are previously defined in the table 1). Using EQ. 9 in EQ.11 we will get EQ.12

$$(EQ.12) \quad CEPC = \alpha_0 + \alpha_1 (NODPC + ORPC) + \alpha_2 D1 + \alpha_3 D2 + \varepsilon$$

The above equation needs to change to meet this paper's theory. Previously, it was stated that disposable income in Iran has two different and important parts, oil and non-oil parts. But EQ.12 restricted the effect of both parts to be the same. This is a restriction which is not supported by the theory which is used in this paper so EQ.13 can better explain the relationship between these variables:

$$(EQ.13)\ Model1:\ CEPC = \beta_0 + \beta_1 NODPC + \beta_2 ORPC + \beta_3 D1 + \beta_4 D2 + \varepsilon$$

This is the simplest model that it can be used as the starting point of this study.[2] Following this simple model, and in order to use the concept of elasticity, the natural logarithm of these variables is used which is shown in EQ.14 and it is the second model[3] of this paper.

[2] Adjustment for autocorrelation has been done through appropriate SAS Procedure (i.e. Proc autoreg).

[3] Adjustment for autocorrelation has been done through appropriate SAS Procedure (i.e. Proc autoreg).

$$(EQ.14)\ \ Model2\text{: } Ln(CEPC) = \ \delta_0 + \delta_1 Ln(NODPC) + \delta_2 Ln(ORPC) + \delta_3 D1 + \delta_4 D2 + \varepsilon$$

The assumption behind the above models is that Ordinary Least Squared (OLS) assumptions are hold.[4] However, this is unlikely to be true. For example, NODPC is not an exogenous variable and its value is determined according to other variables. In other word, instead of a simple regression model, this problem must be modeled through a system of equations in which the value of the variables is determined simultaneously. This means there is a need to define a system of equations and to use appropriate method of estimation, (i.e. 2SLS[5] or 3SLS[6]). EQ.15 through EQ.20 shows the system of equations which is used to estimate the parameters in the third model.

[4] The only exception is autocorrelation which appropriate programming has been considered to remove its effect.

[5] Two Stages Least Squares

[6] Three Stages Least Squares

$$(EQ.15)\ Model\ 3\text{: } Ln(CEPC) = \ \theta_0 + \theta_1 Ln(NODPC) + \theta_2 Ln(ORPC) + \theta_3 D1 + \theta_4 D2 + \varepsilon$$
$$(EQ.16)\ \ Identity\text{: } NODPC = CEPC + GEPC + IPC + OEPC - IMPC - NTPC$$
$$(EQ.17)\ \ ln(GEPC_t) = \vartheta_0 + \vartheta_1 ln(GEPC_{t-1}) + \vartheta_2 Ln(ORPC) + \vartheta_3 D1 + \vartheta_4 D2 + \varepsilon$$
$$(EQ.18)\ \ ln(IPC_t) = \gamma_0 + \gamma_1 ln(IPC_{t-1}) + \gamma_2 Ln(NODPC) + \gamma_3 Ln(ORPC) + \gamma_4 D1 + \gamma_5 D2 + \varepsilon$$
$$(EQ.19)\ \ ln(OEPC_t) = \tau_0 + \tau_1 ln(OEPC_{t-1}) + \tau_2 D1 + \tau_3 D2 + \varepsilon$$
$$(EQ.20)\ \ ln(IMPC_t) = \varphi_0 + \varphi_1 ln(IMPC_{t-1}) + \varphi_2 Ln(NODPC) + \varphi_3 Ln(ORPC) + \varphi_4 D1 + \varphi_5 D2 + \varepsilon$$

ORPC is considered exogenous in the above system. Farzanegan (2011) and Valadkhani (2004) discuss reasons behind assuming ORPC as an exogenous variable. They point out that the level of oil that Iran can sell is determined by OPEC[7] and the price is determined in the market which is not under Iran's control. Therefore although the population would be affected by the government's policy, it is better to assume this variable as an exogenous variable (Farzanegan (2011); Valadkhani (2004)).

IPC, OEPC and IMPC are estimated based on their lagged values and other variables which are supported in the economic theory. The thought process behind using the above equations is to try to find instruments which have high correlation with the values of the main variables (i.e. IPC, OEPC, IMPC and NODPC) and do not have the endogeneity problem.

[7] Organization of the Petroleum Exporting Countries

One may point out that why interest rate and real exchange rate are not used in the above model. The main reason is to have instruments which have the highest possible correlation with the actual variables. However, to address the concern of bias in the results because of the missing variables, the forth model is defined by redefining the "investment," "imports" and "other exports" equations.

The only important issue to mention about the forth model is the investment equation (i.e. EQ. 24). In this equation, inflation rate is used instead of interest rate. Valadkhani (2004) discusses why it is not appropriate to use interest rate when a researcher wants to estimate investment in Iran. He particularly points out the fact that the interest rate is "artificially kept low" by government in Iran (and for a period of time it did not exist) and people use different ways of investment to keep their purchasing power and therefore inflation rate can better explain investment-saving behavior of people in Iran (Valadkhani (2004)). Based on this discussion, the forth model can be defined as:

$$(EQ.21)\ Model\ 4{:}\ Ln(CEPC) = \theta_0{}' + \theta_1{}'Ln(NODPC) + \theta_2{}'Ln(ORPC) + \theta_3{}'D1 + \theta_4{}'D2 + \varepsilon$$
$$(EQ.22)\ Identity{:}\ NODPC = CEPC + GEPC + IPC + OEPC - IMPC - NTPC$$
$$(EQ.23)\ \ ln(GEPC_t) = \vartheta_0{}' + \vartheta_1{}'ln(GEPC_{t-1}) + \vartheta_2{}'Ln(ORPC) + \vartheta_3{}'D1 + \vartheta_4{}'D2 + \varepsilon$$
$$(EQ.24)\ \ ln(IPC_t) = \gamma_0{}' + \gamma_1{}'INF + \gamma_2{}'Ln(NODPC) + \gamma_3{}'Ln(ORPC) + \gamma_4{}'D1 + \gamma_5{}'D2 + \varepsilon$$
$$(EQ.25)\ \ ln(OEPC_t) = \tau_0{}' + \tau_1{}'q + \tau_2{}'D1 + \tau_3{}'D2 + \varepsilon$$
$$(EQ.26)\ \ ln(IMPC_t) = \varphi_0{}' + \varphi_1{}'q + \varphi_2{}'Ln(NODPC) + \varphi_3{}'Ln(ORPC) + \varphi_4{}'D1 + \varphi_5{}'D2 + \varepsilon$$

In the above system of equations, INF is Inflation rate and "q" is the real exchange rate. Due to the shortcoming in the data for INF and real exchange rate, the above system only covers the years from 1976.

In the following section results of the above models are presented and discussed. Moreover sensitivity analysis of the structure of models is used to test the robustness of the results. Two approaches are used for this analysis: first, instead of using variables in log form, the actual value of them is used and second, variables are used in their rudimentary form, i.e. non-per capita form.

Results and Discussion

Results of the Models

Table 3 summarizes the results of four models. For the purpose of simplicity, in the case of the simultaneous equations, only the results for the main model are reported.

Table 3. Regression results of the main models

Model	Model 1	Model 2	Model 3		Model 4	
Variables	$CEPC$	$Ln(CEPC)$	$Ln(CEPC)$ (2SLS)	$Ln(CEPC)$ (3SLS)	$Ln(CEPC)$ (2SLS)	$Ln(CEPC)$ (3SLS)
Intercept	0.33 *** (4.14)	-0.28 *** (-10.01)	-0.30 *** (-10.37)	-0.30 *** (-10.42)	-0.43 *** (-6.46)	-0.45 *** (-6.78)
$NODPC$	0.58 *** (27.6)					
$Ln(NODPC)$		0.87 *** (26.39)	0.87 *** (27.19)	0.88 *** (27.45)	0.94 *** (21.08)	0.95 *** (21.44)
$ORPC$	-0.11 ** (-2.37)					
$Ln(ORPC)$		-0.09 *** (-2.88)	-0.07 ** (-2.31)	-0.08 ** (-2.59)	0.00[8] (0.02)	0.01 (0.19)
D1	-0.13 (-1.63)	-0.08 * (-1.78)	-0.06 (-1.39)	-0.07 (-1.63)	0.02 (0.37)	0.02 (0.47)
D2	0.24 *** (4.42)	0.08 *** (2.96)	0.08 *** (3.21)	0.08 *** (3.17)	0.11 *** (4.07)	0.11 *** (4.22)
Observations	48	48	46	46	37	37
R-Square/ System weighted R-Sq	0.9724	0.9747	0.9753	0.9726	0.94470	0.9128
F-value	379.21 ***	413.43 ***	414.59 ***	431.81 ***	140.94 ***	154.33 ***
Root Mean Square Error	0.13	0.06	0.06	0.06	0.06	0.06

*Significance levels are indicated as * p = .10; ** p = .05; and *** p = .01*
t-Statistics in parentheses.
All numbers are rounded to two decimals (only exception is R-Square)

8 The Original value is 0.000873

Results shown in the table 3 are common in one fact: none of the models is able to show a positive relationship between the oil revenue and consumption expenditure in Iran. Although the results of last model do not show a negative relationship between oil revenue and consumption expenditure but still there is no statistically significant positive relationship between these two variables (note that the last model only covers the years from 1976). One should note that the coefficient of *Ln(ORPC)* in model 2 through 4 shows the oil-revenue elasticity of consumption which is very small (i.e. consumption expenditure is inelastic to the changes in oil revenue).

On the other hand, it is found that consumption expenditure is highly dependent on non-oil disposable income. Revolution in Iran didn't find to be statistically significant but the 8 years war was found positively influential on the private consumption.

The main result of all models, i.e. statistically insignificant effect of oil revenue on consumption expenditure, is completely unlike what was expected because of the oil-dependent nature of Iran's economy. Therefore this study needs to continue further and consider some other type of models which may help to reconcile this dilemma. These models and the results of them are discussed in the next section.

Sensitivity Analysis

Here, results of two alternative types of models are presented. The first type is the revision of Model 3 and 4 in which all of the variables are used in their simple form (non-log form). The results of these models are shown in table 4 (under the title "version 2").

The other type uses the same structure used in models 3 and 4 but the variables are in their simplest form, i.e. they are not in log form or per capita form. Table 4 also includes the results of these models (under the title "version 3"). To keep the table simple, only the value of interested variables is shown.

Table 4. Sensitivity analysis: Regression results of the alternative models

Model	**Model 3 (version2)**		**Model 4 (version2)**		**Model 3 (version3)**		**Model 4 (version3)**	
Variables	$CEPC$ (2SLS)	$CEPC$ (3SLS)	$CEPC$ (2SLS)	$CEPC$ (3SLS)	CE (2SLS)	CE (3SLS)	CE (2SLS)	CE (3SLS)
ORPC	-0.10 * (-2.00)	-0.13 ** (-2.54)	0.00[9] (0.05)	-0.00[10] (-0.09)				
OR					-0.11 (-1.64)	-0.13 * (-1.90)	-0.01 (-0.10)	-0.03 (-0.24)

*Significance levels are indicated as * p = .10; ** p = .05; and *** p = .01*
t-Statistics in parentheses.
All numbers are rounded to two decimals.

[9] The original value is 0.004369
[10] The original value is -0.00832

Table 4 shows vividly that oil revenue does not affect consumption expenditure in a positive way. This is in line with the results of the main models of this paper.

Conclusion and Policy implication

Iran is known as an oil-dependent country and it is expected to observe the importance of oil revenue in different aspects of its economy. One of the main dimensions of Iran's economy which has been studied by various researchers is the government expenditure. Different researchers have shown a positive relationship between government expenditure and oil revenues. The other dimension which has not been addressed in other studies is consumption expenditure. Unlike what it was expected, the results of this paper failed to support the hypothesis that the oil revenue is significantly and positively related to the consumption expenditure. In fact, according to some models used in this study, this relationship found to be statistically significant and negative although it was not economically significant. This result leads to a question about the reason behind this phenomenon, which is beyond the scope of this study and can be suggested for further research.

An important limitation in using the result of this study is related to the nature of data. Data used for this study exhibit some degrees of fluctuations in the oil revenue but it does not include any radical change. Oil revenue has been always an important source of national income in Iran.

This study failed to find the possible harmful effect of U.S. decision of limiting Iran's oil revenue on consumption expenditure of people in Iran or as it was defined early in the paper, their welfare. However, because of the above mentioned limitation, the possible effect of a complete international embargo against Iran's oil cannot be forecasted according to the available data.

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le of Contents

Appendix A: Data

Year	C	G	I	OE	IM	OR	EX	NT	Pop	CPI	q
1960	26152.28	4126.20	12257.83	1319.99	9188.84	14952.59	16272.59	2872.15	21999103.00	0.29	
1961	26251.14	4008.78	13997.55	1418.02	8753.24	16826.95	18244.97	2854.11	22571865.00	0.30	
1962	26777.37	4140.29	14130.95	1323.37	8083.80	19326.66	20650.03	2962.89	23163924.00	0.30	
1963	27099.24	4487.86	13980.50	1384.22	7648.20	21359.88	22744.10	3354.22	23775945.00	0.30	
1964	26141.81	5457.77	17193.81	1477.18	10729.49	24091.14	25568.31	3367.96	24408927.00	0.31	
1965	27341.56	7155.68	21864.05	1789.85	12352.67	27968.30	29758.15	4147.28	25063612.00	0.32	
1966	29848.67	8062.18	24228.64	1610.70	14049.21	31864.05	33474.75	5340.93	25743217.00	0.32	
1967	33012.56	9137.76	26450.19	1815.20	17456.05	37088.25	38903.45	5760.31	26448218.00	0.32	
1968	32539.27	10781.67	34383.23	2161.68	20977.52	42276.95	44438.63	6772.25	27173692.00	0.32	
1969	35145.84	12690.95	36391.58	2251.26	23421.46	50327.05	52578.30	7811.98	27912687.00	0.33	
1970	38769.31	14752.88	40473.53	2548.72	25228.05	56703.92	59252.63	8581.99	28662011.00	0.34	4432.63
1971	44483.19	19066.95	39464.67	3403.93	30148.03	66045.27	69449.20	8917.59	29421198.00	0.35	4435.16
1972	46981.73	23928.21	53004.20	3324.49	35058.83	76103.25	79427.74	9778.19	30197689.00	0.38	4306.23
1973	53227.21	25499.32	46958.02	9795.76	44522.87	78745.16	88540.92	7202.69	31006191.00	0.41	3787.49
1974	65042.52	41247.93	80758.93	9308.50	79990.93	77612.24	86920.74	2358.05	31866190.00	0.47	3613.79
1975	85514.39	50160.24	111075.08	9672.30	120908.88	68363.59	78035.89	4271.83	32793173.00	0.53	3494.38
1976	85221.15	55643.84	133339.37	8377.00	118228.90	78145.04	86522.04	5362.87	33788867.00	0.59	3448.02
1977	91274.57	54180.77	138388.27	8452.60	134008.71	71277.75	79730.35	7821.95	34853522.00	0.76	2900.78
1978	93124.89	55115.44	106310.82	6896.22	93401.72	51134.68	58030.90	6991.75	35998637.00	0.84	2789.42
1979	96290.51	51132.50	77557.75	6264.76	70412.70	38954.12	45218.88	149.71	37237306.00	0.93	2808.99
1980	91906.84	46226.61	84088.12	3931.00	71825.05	11396.15	15327.15	4128.68	38576541.00	1.13	2648.07
1981	94613.22	45745.19	75040.15	1953.20	68068.14	11736.56	13689.76	2520.51	40012129.00	1.40	2609.67
1982	101500.52	44857.48	73065.46	1513.70	60733.09	24953.13	26466.83	3524.47	41533339.00	1.66	2491.25
1983	116157.79	45327.16	97495.09	1993.90	84264.74	30266.40	32260.30	6924.92	43130529.00	1.99	2218.21
1984	122405.19	42525.48	69037.09	1819.60	57908.48	23783.92	25603.52	7826.49	44790735.00	2.24	2142.41
1985	124500.04	44575.66	60793.82	1581.30	53889.10	21608.29	23189.59	8123.78	46497235.00	2.33	2149.41
1986	111887.20	35405.02	65971.45	906.90	46919.93	18500.25	19407.15	7324.68	48257311.00	2.76	1600.10
1987	105039.55	32943.86	77412.58	5446.20	51612.48	22881.11	28327.31	6432.46	50052662.00	3.55	1170.43
1988	105837.07	32786.52	57973.86	4462.34	43924.24	27837.14	32299.49	4465.90	51810746.00	4.57	909.84

1989	109428.05	31367.82	69967.81	5527.42	52991.08	29338.58	34866.00	5232.82	53437770.00	5.59	817.36
1990	112822.73	32598.61	101028.70	7914.82	69743.24	36374.86	44289.68	5125.47	54870583.00	6.02	756.86
1991	123326.96	34781.96	127567.84	12095.53	92826.27	39784.30	51879.83	6796.84	56071545.00	7.05	667.69
1992	128023.55	34473.95	122145.88	12934.80	84378.12	40782.38	53717.18	7716.38	57067645.00	8.87	530.97
1993	131263.69	41121.90	90175.28	18805.54	67808.85	43196.41	62001.95	-199.65	57940444.00	10.75	8722.98
1994	132870.31	41508.59	61013.21	26310.48	41336.53	39697.70	66008.18	-2380.35	58808655.00	14.13	9392.16
1995	130900.53	40296.08	80171.28	13876.87	40952.97	38388.69	52265.56	-3207.67	59757114.00	21.15	6448.98
1996	134954.16	39671.60	103388.50	13565.07	47816.22	39997.31	53562.38	-710.97	60815686.00	27.27	5156.57
1997	140807.48	38206.70	104619.31	13464.65	44727.51	37541.95	51006.60	909.20	61955730.00	32.00	4502.51
1998	150536.86	39739.79	101391.76	18237.53	44886.79	38107.42	56344.95	559.39	63133032.00	37.72	3876.96
1999	154730.09	37150.33	103227.85	19857.31	42520.89	37658.62	57515.94	1572.75	64278307.00	45.29	3301.56
2000	165924.59	41615.71	111082.81	18565.99	46047.25	39912.75	58478.75	2209.57	65342319.00	51.84	13854.51
2001	173287.45	42687.65	108524.66	21855.16	54006.26	35538.00	57393.16	3539.38	66313553.00	57.69	12447.60
2002	193565.04	43632.72	126435.91	25370.47	66566.11	36835.50	62205.97	3695.22	67212850.00	65.96	9645.22
2003	203790.84	44890.44	148088.54	27081.67	80261.55	42931.00	70012.67	4857.54	68061695.00	76.82	10047.23
2004	228348.17	48209.35	157135.05	25298.00	90635.85	44635.00	69933.00	3750.00	68893323.00	88.16	9450.35
2005	251086.76	51107.32	153183.00	29045.28	92645.29	44618.70	73663.98	-5437.00	69732007.00	100.00	8963.96
2006	266322.29	54062.92	164201.98	33325.93	99241.34	46258.80	79584.73	-7543.00	70582086.00	111.94	8457.07
2007	284441.07	49460.74	194924.81	31656.04	102335.94	46653.80	78309.84	-1400.00	71435498.00	131.21	7509.64

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Economic Impact of Federal Spending on Agriculture and Rural Economic Development Programs in Mississippi, 2010

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Introduction

The looming budget battles and potential cuts could significantly change Mississippi in various areas such as, agriculture, community development, income stability, health and nutrition, and other programs in the state. According to the 2010 Consolidated Federal Funds data, Mississippi received more than $53.7 billion in grants, subsidies, direct loans, retirement and disability benefits, other direct payments to individuals, direct payments not to individuals, guaranteed loans, procurement contracts, and salaries and wages.

Many programs, up for discussion either for elimination or reduction, contribute to Agriculture and Rural Economic Development (ARED) for producers and households in rural communities in Mississippi and the U.S. Decreasing ARED expenditures would have minimal impact on solving the national debit and could hurt Mississippi's economy. These programs provide a critical and reliable source of income and support for the thousands of farmers, households, and rural communities that benefitted from them in the state. This stable source of income turns over many times in the state's economy in the form of revenues for local businesses and various levels of government.

The challenge issued to the Agriculture Appropriations Committee was to cut $3.2 billion of discretionary spending from their budget of $23.3 billion. Many of these funds help to subsidize agriculture, health, nutrition, and quality of life in both rural and urban areas of Mississippi and the U.S. Deciding where to make these cuts is complicated because many programs in the federal budget are interconnected. For example, some programs that USDA controls not only target farmers and landowners but low-income and poverty households as well. Cutting funding for agriculture will indirectly reduce support for disadvantage families in Mississippi.

Overview

In 2010, the federal government provided more than $1 billion in ARED funding (Table 1) to Mississippians of all ages. This accounted for 1.41percent of total personal income ($92.23 billion) in the state during this period. Thus, cutting the benefits would also reduce the personal income for these recipients.

Table 1. Federal Spending on Selected Agriculture and Rural Economic Development Programs in Mississippi, 2010

Program Category	Total Spending
Agriculture, animal, and forestry research	$44,532,512
Agriculture education and conservation	74,910,012
Agriculture finance	724,157,735
Agriculture insurance	215,515,095
Environmental and water quality	35,362,116
Farm and ranch program	317,466
Farm buildings	3,347,708
Fisheries	20,994,912
Food and health safety	1,656,264
Mining	496,322
Real estate	1,150,000
Recreation	105,489
Rural and technology grant	124,478
Total	1,122,670,109

Source: Summarized from 2010 CFFD Report for Mississippi.

Purpose

The primary focus of this paper was to address how potential cuts in federal spending for agriculture will impact the economy of Mississippi. Many farmers and agricultural support organization are concerned that this industry will shoulder a disproportionate share of deficit reductions compared to its total share of the federal budget. They say that they will take additional cuts on top of the $6 billion reduction because of the Standard Reinsurance Agreement (SRA) for crop insurance in 2010.

Data and Methods

The data used for this analysis came from three sources—Consolidated Federal Funds Data and Bureau of Economic Analysis both for 2010 and IMPLAN 2010. To perform the analysis, the paper used federal funds data for Mississippi and counties in 2010. The analysis summarized federal spending in all programs related to agriculture and rural development to determine the total amount of federal aid the state received in 2010. An Excel-based spreadsheet model allowed the author to run queries on various agriculture spending, using the latest available federal funds data for Mississippi. The results and tables show the proportions of federal spending on agriculture in the state in 2010.

The data obtained from spreadsheet queries were analyzed, summarized, and then included in the input-output model. Total federal spending on agriculture forestry, land, and other natural resource programs described the changes in final demand that federal subsidies had on the state's economy in 2010.

The Input-Output (I-O) modeling software known as IMPLAN 3.0 (Minnesota IMPLAN Group, Inc.) was used to perform the analysis. The latest statewide dataset available for this model was the 2010 Mississippi dataset and consisted of 440 different industries. Direct effects were bridged to IMPLAN by assigning specific CFFD spending values to the appropriate IMPLAN sectors. After creating the state-level model for Mississippi, impact scenarios were used to assess the impact of reduced spending on agriculture and other programs on the state's economy.

The author simulated the economic impacts of reducing ARED spending by 5%, 10%, and 15% in Mississippi. Each scenario provided a detailed view of how a decrease in these expenditures would affect individuals receiving these benefits and how the economy might react to decreases in spending in the state. Changes in employment, income, output, and public finances reflected the exogenous shocks of decreases in ARED spending in Mississippi. Economic impact measures the net change in the state's economy resulting from changes in these programs.

Results

Current Impact

In this section we conducted an economic impact analysis of ARED spending at the state level in Mississippi, using the IMPLAN model. Each class of program spending was included in the model as direct benefits to Mississippi. Program categories were then bridged into IMPLAN based on the sector that reflected the spending for each program in the model.

The impact results suggested that ARED spending created 9,106 jobs directly in the Mississippi economy and 6,951secondary jobs in other businesses in the state's economy in 2010. The total jobs generated because of this spending equaled 16,057 in Mississippi.

Estimates of employee compensation revealed that almost $543.6 million in salaries and wages were received by workers in the state and attributed to federal spending on ARED programs in 2010. In addition, because of ARED spending, about $269.67 million in proprietor and other property type of income were directly generated in Mississippi and about $174.23 million in secondary income were generated in other businesses throughout the state's economy.

Table 2. Economic Impact of Federal Spending on Agriculture and Rural Economic Development Programs in Mississippi, 2010

Program Category	Employment	Output	Employee compensation	Total Value added
Agriculture, animal, and forestry research	328	44,867,465	14,806,850	20,038,657
Agriculture education and conservation	2,517	75,006,030	56,173,795	60,860,776
Agriculture finance	3,545	828,055,897	187,093,956	406,337,812
Agriculture insurance	2,489	261,243,769	101,456,432	174,479,097
Environmental and water quality	388	36,138,574	15,158,330	22,047,656
Farm and ranch program	5	487,117	26,345	80,835
Farm buildings	30	3,347,708	861,528	1,258,542
Fisheries	641	20,998,391	985,440	14,317,150
Food and health safety	48	2,404,208	1,273,986	1,433,662
Mining	4	505,536	99,351	291,416
Other	5,669	547,883,556	158,898,506	299,869,784
Real estate	284	26,405,698	1,852,979	19,131,332
Recreation	38	2,204,491	882,608	1,354,891
Rural and technology grant	69	22,876,558	3,997,589	12,701,324
Total	16,057	1,872,424,998	543,567,695	1,034,202,933

The total impact on businesses from ARED spending was $1,872.43 billion, of which, $749,755 million was secondary spending with other businesses throughout Mississippi's economy.

Value added reflected the net estimate of the creation of "new value" in the economy. It included the value of employee compensation, profits, indirect business taxes, rents, and other aspects of production, but excluded the costs of purchased materials and services.

The author estimated that federal spending on ARED programs in Mississippi supported more than $1.035 billion in value added income in 2010. The expenditure multiplier was greater than one and suggested how much additional economic activity was gained in other areas of Mississippi's economy for each dollar of ARED spending. The multiplier varied in size because of differing levels of economic diversity found in the state. For Mississippi, the multiplier was 1.67, suggesting that for every dollar of increase (or reduction) in ARED spending an additional $.67 was created in 2010.

Reducing ARED Spending

Reducing federal spending on ARED in Mississippi would ripple throughout the state' economy, reducing employment, income, business spending, and public finances in a state that is already struggling to balance its budget and provide basic services to its citizens. The IMPLAN model estimated that decreasing ARED spending by 5 percent would decrease employment by 803 jobs in the state (Table 3). Eliminated with these jobs would be $27.18 million in salaries and wages and almost $93.62 million in sales to businesses in 2010. The loss in sales and other spending would reduce local, state, and federal taxes by $9.13 million during this period.

Table 3. Economic Impact of Reducing Federal Spending on Agriculture and Rural Economic Development Programs in Mississippi, 2010

		Reduction		
Item	Current	5%	10%	15%
Employment	16,057	(803)	(1,606)	(2,409)
Employee compensation ($)	543,567,695	(27,178,385)	(54,356,770)	(81,535,154)
Value added ($)	1,034,202,933	(51,710,147)	(103,420,293)	(155,130,440)
Output ($)	1,872,424,998	(93,621,250)	(187,242,500)	(280,863,750)

These reductions in economic activity would further slow economic recovery and effect local and state governments. This would also limit the federal governments' ability to provide basic services and promote economic development to states who needs help such as Mississippi.

Local and state taxes resulting from ARED spending totaled $71.86 million in Mississippi in 2010 (Table 4). Federal taxes generated from ARED spending in Mississippi equaled $110.71 million during this period. Combined, local, state, and federal taxes contributed $182.57 million in total revenues to the Mississippi and U.S. economies in 2010. Cutting federal spending on ARED programs by 15 percent in Mississippi would have reduced state revenues by almost $10.8 million in 2010.

Table 4. Economic Impact of Reducing Federal Spending on Agriculture and Rural Economic Development Programs on Tax Receipts in Mississippi, 2010

		Reduction		
Taxes	Current	5%	10%	15%
Local and state ($)	71,850,354	(3,592,518)	(7,185,0350	(10,777,553)
Federal ($)	110,740,819	(5,537,041)	(11,074,082)	(16,611,123)

Conclusions

Regardless of the conditions, federal spending on ARED programs in Mississippi provided an economic boost to local businesses and workers in 2010. A policy to reduce spending on these programs would have clear impacts on business spending, employment, income, and public finances in the Mississippi economy.

Mississippians benefited from more than $1.1 billion in ARED spending in 2010. Expenditures resulting from this spending supported almost $543.57 million in employee compensation for workers in the state. More than 16,057 jobs were attributed to ARED spending in Mississippi in 2010. ARED spending supported another $749.75 million in economic output (bringing the total output to $1.88 billion) in the state and more than $1.03 billion in value added. Each dollar of ARED spending supported an additional $.67 in other spending throughout Mississippi in 2010.

Spending on these programs in Mississippi supported more than $182.59 million in local, state, and federal tax revenues during this period. Overall, economic activity would have declined by .058 percent during this period in Mississippi.

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Measuring the Economic Impact of ASDI Benefits

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Introduction

This paper focuses on the role Social Security, particularly Old Age Survivor Disability Insurance (OASDI, plays in one of the nation's most dependent counties, Sumter County, Florida. These benefits are important in providing a stable source of income for communities in which the recipients live and spend their checks. In recent years, however, there have been serious discussions about reducing the economic footprint of social security in the federal budget.

The OASDI program provides monthly benefits to eligible retired and disabled workers and their dependents and to survivors of insured workers. Workers' contributions to Social Security determine their eligibility and benefit amounts. Using data from the social Security Trustees Report, about 6 percent of the Florida's gross domestic product comprised these cash benefits in 2009.

According to data from the Social Security Administration, almost 3.7 million Floridians received OASDI payments during 2009. This was about 19.8 percent of the state's total population in that same year. Similarly and according to the Bureau of Economic Analysis, the disbursements of OASDI total almost more than $47 billion dollars[1] in 2009. This figure accounted for 6.5 percent of total personal income[1] and resulted in an average per capita (residents) payment of $2,547 dollars.

Data and Methods

The data used in this analysis came from three sources—Bureau of Economic Analysis (BEA), Social Security Administration, Office of Retirement and Disability Policy, and IMPLAN MIG all in 2009 (Appendix A Table 1). The author used the latest data (2009) from BEA on OASDI benefits for Sumter County, Florida and the state to perform the analysis.

The author used the IMPLAN Input-Output model to simulate the economic impacts of reducing OASDI benefits by 5%, 10%, and 15% on the target regions in the U.S. Each scenario provided details on how a decrease in OASDI benefits would affect individuals receiving these benefits and how the economies in the target areas might react to decreases in the personal income and spending.

Examination of exogenous shocks occurred in terms of changes in employment, income, output, and public finances in Sumter County, Florida and the state. Economic impact measures the net change in the region's economy resulting from changes in these events. From these results, it was possible to determine how much overall economic activity would decline in the region in 2009.

Research Questions

This paper addressed three important questions. First, how dependent is Sumter County on OASDI payments? Second, what is the economic impact of OASDI payments in Sumter County and Florida? Third, what would be the economic impact of potential reductions in

Table of Contents

OASDI payments on the economies of these areas?

Analysis and Results

To address the question on dependency, the author calculated two types of indices to gain insight into these issues. The first index was the traditional population based dependency index (PBDI). The basis behind this index is that it relates the number of persons under age 19 and over age 65 to those in the age range 20 – 64 in the population. This ratio is a measure of how many recipients depend on each 100 persons of working age populations in the area. Calculations of the index occurred at both the county level (i.e., Sumter) and state level in Florida for the periods 1990, 2000, and 2010. Time series data on population by age breakdown were not available for the period 1999 to 2009.

The second index was the government dependency index (GDI) and included expenditures for six selected programs in Sumter County and the state of Florida between 1999 and 2009. County and state level indices were calculated for the period 1999 to 2009. To answer the second question, economic impact analyses of the most dependent county in the U.S and the state which houses this county were conducted during the period 2009.

Dependency

Table 1 provides detailed data on population and age dependency ratios for years 1990, 2000, and 2010. The table shows the calculated trends in age or demographic-dependency (DDI) ratios in Sumter County, Florida and the state during these periods.

Table 1. Age Dependency Ratios for Sumter County, Florida and State, 1990, 2000, 2010

		Children	Working Age	Older persons	All Dependents	Working age	Older persons
Year	Total Population	0 - 19	20 - 64	65+	(per 100 persons of working age)		
Sumter County							
1990	31577	7907	16604	7066	90.18	47.62	42.56
2000	81657	14406	45488	21392	78.70	31.67	47.03
2010	93,420	9493	43397	40530	115.27	21.87	93.39
Florida							
1990	12937926	2851781	7497601	2281083	68.46	38.04	30.42
2000	15,982,378	4,048,632	9,126,149.0	2,807,597	75.13	44.36	30.76
2010	18,801,310.00	4,512,990	11,028,718	3,259,602.00	70.48	40.92	29.56

The population dependency ratio for Sumter County reached its height of 115.12 in 2010- meaning there were 115.12 dependents per 100 persons of working age in the county. In 1990, there were 90.18 (of which 47.62 were children and 42.52 were older persons) dependents per 100 persons of working age. The higher the ratio, the less people the county had for productive work to support payments of OASDI to those who were too old or not able to work. However, focusing only on demographic changes was simply not good enough. This ratio does not suggest anything about the working age population, economic productivity, or whether the older person and children are economically dependent. It is conceivable that a county, state, or nation's ratio could reach a point that would lead to economic instability.

The government dependency index (GDI_w) reflects the dependence of Sumter County, Florida and state residents who rely on the selected government programs[1] to meet their basic living needs. The following section provides estimates of the GDI_w for Sumter County and the state of Florida from 1999 to 2009. This index borrows from the index of dependence on government published annually by the Heritage Foundation since 2002[2].

Multiplying the raw values (i.e., annual expenditures) by the weights[3] for each program and summing the weighted values for that year (Appendix C Table 1) produced GDI_w . The formula construction of the index is:

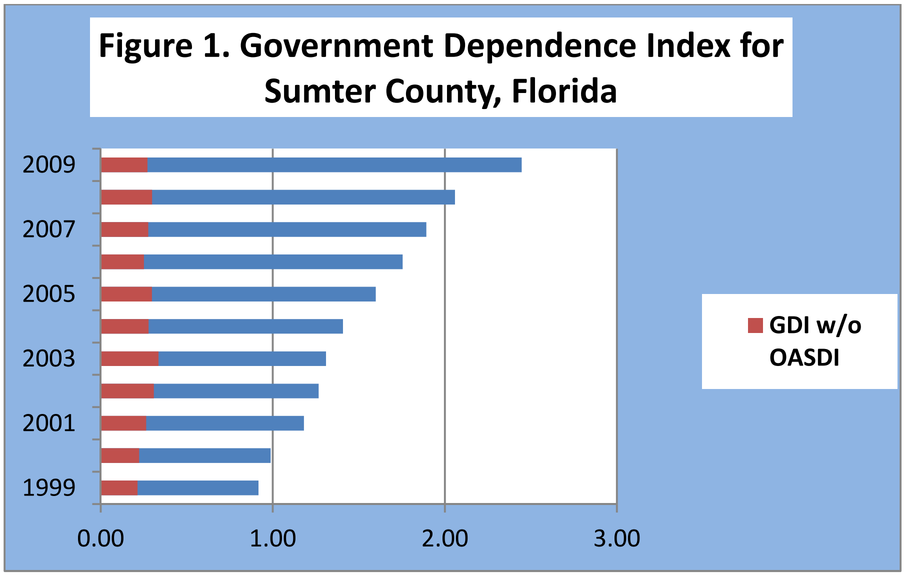
$$GDI_{it} = \frac{\sum_{i=1}^{n}(Gp_{it} * Wgp_{it})}{\sum_{i=1}^{n}(Wgp_{it})}$$

Where:
GDI = government dependent index
Gpi_t = government program i in year t
Wgp_{it} = Normalized weight of government program i in year t
i = ith government program
t = year of government program
N = number of government programs

The base year for the index was 1999 and this meant the weighted value for 1999 equals 100 percent. This provided a reference point to compare future indices.

GDI_w provides insight about the speed at which residents in the target areas depend on the selected federal programs for subsistence. Figure 1 provides a visual snapshot of the GDI for Sumter County from 1999 to 2009. An increase in the index from one year to the next indicates an increase in dependency while a decrease in the index shows a decline in dependency in the local area. This figure clearly shows how the important share of OASDI benefits was in total household income in the county during this period. With OASDI, the average person in Sumter County received about $2, 450 compared to only $270 person without OASDI in 2009.

According to our analysis, residents of Sumter County dependence on these government programs increased more than 166 percent between 1999 and 2009. This compared with an increase of almost 63 percent for Floridians as a whole during this period. The dramatic rise in Sumter County's government dependence started in earnest in 2005, growing about 153 percent by 2009.



Excluding OASDI benefits (GDI_{wo}) from the analysis, showed how markedly different the results were in 2009. For Sumter County, government dependence would have grown on 28.57 percent between 1999 and 2009. Without OASDI benefits, government dependence on the remaining selected programs would have declined 10 percent between 2005 and 2009. Compared to the state, without OASDI benefits government dependence would have increased 122 percent between 1999 and 2009. Between 2005 and 2009, government dependence absent OASDI benefits would have increased 25.71 percent.

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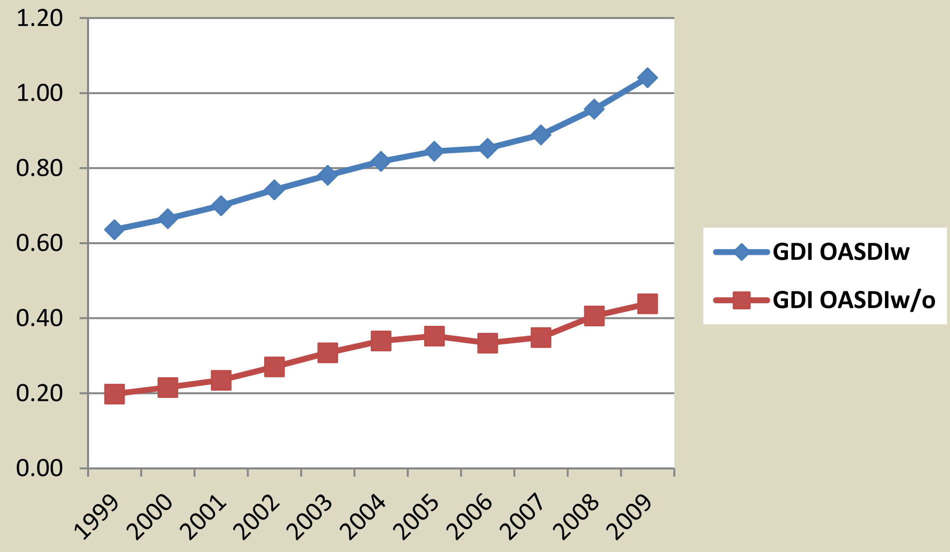
[1] The selected programs and values used in calculating the index are in Appendix B Table 1 and based on data from the Bureau of Economic Analysis (BEA) Table CA35.

[2] The Heritage Foundation, at http:://report.hertiage.org/bg2419

[3] The weights are the normalized rankings of raw values in each program and year. Normalizing the weights means for each year they will sum to one.

Figure 2 provides a snapshot of the GDI for the state of Florida from 1999 to 2009. Again, an increase in the index from one year to the next suggested an increase in dependency while a decrease in the index reflected a decline in dependency in the local area. This figure also showed how significant the share of OASDI benefits was in total household income in the state. With OASDI, the average Florida resident received about $1,040 compared to only $440 person without OASDI in 2009.

Figure 2. Government Dependence Index for State of Florida



Another way of looking at these results is that Sumter County residents depended on these selected programs 2.66 times more in 2009 than in 1999. Similarly, for the state of Florida, the results suggested that Floridians dependence on these government programs grew 62.5 percent during this period.

Economic Impact

In this section we conducted an economic impact analysis of OASDI payments in Sumter County, Florida and the state (which has a high SSDI[4] score according Gallardo and Myles, 2011) using an input-output modeling system known as IMPLAN. The author used each county's adjusted[5] [1] OASDI benefits as direct payments to households in the model. Median household incomes in the state and county served as proxy measures for household income in the model. IMPLAN's household spending profiles closest to the median county and median state incomes served as proxies in the model.

The author looked at total output, employment, and tax revenues using 2009 OASDI spending and incorporated three different scenarios into the model. These scenarios examined 5%, 10%, and 15% reductions in OASDI benefits and their impacts on output, employment, and tax revenues in the targeted areas.

Expenditure Effect

[4] SSDI is a social security dependency index derived by Gallardo and Myles in their paper titled "*Economic Impact of Social Security in the United States: Technical Report.*"

[5] OASDI benefits for the U.S. and county analyzed were adjusted by an average propensity to consume (APC) to obtain net OASDI benefits using the Bureau of Economic Analysis' 2009 National Income and Product Accounts savings rate of 5.46% (i.e. an APC of 94.54%).

The expenditure multipliers examined for Sumter County and the state of Florida were greater than one and suggests that for each dollar of reduced OASDI benefits, additional economic activity declined somewhere else in these economies in 2009. The multipliers varied in size because of differing levels of economic diversity found in the county and state in the study.

At the state level, 2009 OASDI payments (about $47 billion) had a multiplier of 1.94 or for every dollar spent on OASDI payments and additional 94 cents occurred in the Florida economy. In other words, Florida's 2009 OASDI payments supported a total output of $91 billion dollars. For employment, this same amount supported approximately 371,725 jobs (includes full and part-time) in the state. Tax revenues totaled $203.3 million of which $55.6 million were state/local taxes and $147.7 were federal taxes.

In Sumter County, the 2009 OASDI payments (about $622 million) had a multiplier of 1.5 or for every dollar spent on these benefits an additional 50 cents occurred in other parts of the local economy. Thus, 2009 OASDI payments supported a total output in the local economy of $938 million dollars. Regarding employment, OASDI payments supported approximately 3,077 jobs (includes full and part-time) and $41 million in taxes of which $20.3 million were state/local taxes and $20.8 million were federal taxes. Table 3 shows a summary for Sumter County, Florida and the state.

Reduction Scenarios

What would be the economic impact of a reduction on OASDI payments? To address this question, the author modeled three different scenarios: a 5%, 10%, and 15% reduction on 2009 OASDI spending. The results for the Florida are shown in Table 3 while Table 4 shows the results for Sumter County in Florida.

Table 3. Florida OASDI Reduction Results in 2009

	Current	5%	10%	15%
Output	$91 billion	-$4.5 billion	-$9 billion	-$13.5 billion
Employment	371,725	-18,586	-37,173	-55,759
Tax Revenues	$5.87 billion	-$293.5 million	-$587 million	-$881 million

Reducing OASDI payments 5% in Florida, economic output would decrease by $4.5 billion, employment by 18,586, and tax revenues by $293.5 million in 2009. Imposing a 15% reduction in 2009 OASDI payments would reduce state's economic output by almost $13.5 billion dollars, employment by 55,759, and tax revenues by $881 million during this period.

Table 4. Sumter County, FL OASDI Reduction Results

	Current	5%	10%	15%
Output	$938 million	-$46.9 million	-$93.8 million	-$140.7 million
Employment	3,077	-154	-308	-462
Tax Revenues	$43.55 million	-$2.18 million	-$4.35 million	-$6.53 million

The impact of OASDI reductions would also affect Sumter County, Florida. Reducing the 2009 OASDI payments in the county by 15% would cause economic output to shrink more than $93 million dollars, employment by 462 , and tax revenues by $6.5 million during this period.

Conclusions

The goal of this paper was to describe the importance and role OASDI payments play in Sumter County and Florida economies. OASDI spending supported about 371,725 jobs in Florida and highlights the importance of these payments in 2009. The erratic nature of demographic dependency measures used in the study showed that Florida and Sumter County ranked high in dependency in some years during this period. However, including OASDI payments in a second dependency measure, the results implied that these payments may be more important than what they seem in reducing dependency in an area. Without OASDI benefits, government dependence in Sumter County would have grown 28.57 percent between 1999 and 2009. Compared to the state, without OASDI benefits, government dependence would have increased 122 percent during this period. Finally, we must mention that this paper is only the first step to understanding an important and complex topic such as OASDI.

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Appendix A, Table 1. Selected Data Used in Developing Results in the OASDI Impact Report

State of Florida

YEAR	Population	Personal Income(000s)	Florida GDP (millions)	Employment	Number of OASDI beneficiaries	OASDI Benefits (000s)
1999	15,759,421	430,693,545	450,382	8,566,924	2,327,961	27,278,199
2000	16,047,118	466,644,105	481,115	8,841,607	2,482,741	28,724,112
2001	16,353,869	487,498,511	506,413	8,917,152	3,239,295	30,468,640
2002	16,680,309	508,399,908	535,934	9,055,999	3,279,994	32,058,437
2003	16,981,183	531,218,073	573,739	9,286,023	3,330,425	33,341,211
2004	17,375,259	582,765,910	621,251	9,661,605	3,384,956	35,002,091
2005	17,783,868	633,192,675	680,277	10,087,925	3,430,205	36,927,965
2006	18,088,505	690,268,109	730,191	10,407,355	3,444,546	38,902,637
2007	18,277,888	721,051,518	759,572	10,577,330	3,477,190	40,926,184
2008	18,423,878	739,403,128	747,770	10,304,809	3,547,492	43,014,476
2009	18,537,969	722,328,176	732,782	9,840,243	3,669,375	47,210,608

Sumter County, FL

YEAR	Population	Personal Income(000s)	Employment	Number of OASDI beneficiaries	OASDI Benefits (000s)
1999	51,725	788,640	12,178	15,895	138,246
2000	53,554	843,454	12,573	17,138	155,252
2001	54,709	963,373	13,321	19,730	189,985
2002	57,482	1,046,154	14,570	20,890	210,415
2003	58,797	1,165,193	17,040	21,300	220,110

2004	60,069	1,323,249	18,558	23,505	254,345
2005	63,405	1,538,018	21,483	26,920	307,580
2006	68,577	1,804,163	23,927	31,035	378,168
2007	72,711	2,002,521	24,686	33,725	431,318
2008	75,219	2,233,905	24,162	36,545	485,813
2009	77,681	2,350,557	23,578	43,005	612,427

Appendix C, Table 1. Government Dependence Index with OASDI and without OASDI Benefits

Year	Sumter County GDI_w		Florida GDI_w	
	OASDI w	OASDI w/o	OASDI w	OASDI w/o
1999	0.92	0.21	0.64	0.20
2000	0.99	0.22	0.67	0.22
2001	1.18	0.26	0.70	0.23
2002	1.27	0.31	0.74	0.27
2003	1.31	0.34	0.78	0.31
2004	1.41	0.28	0.82	0.34
2005	1.60	0.30	0.85	0.35
2006	1.75	0.25	0.85	0.33
2007	1.89	0.28	0.89	0.35
2008	2.06	0.30	0.96	0.41
2009	2.45	0.27	1.04	0.44

Appendix B, Table 1. Government Expenditures on Selected Programs in Sumter County and Florida (000$)

Year	SS benefits	PAMC benefits	Family assistance (FA)	(SNAP)	OIM benefits	OTROIFG
Sumter County						
1999	138,246	25,476	1,258	3,202	6,594	69
2000	155,252	28,311	1,512	2,425	6,857	103
2001	189,985	35,631	2,131	2,534	6,553	205
2002	210,415	44,325	2,320	2,830	7,874	91
2003	220,110	48,800	2,194	2,938	9,696	72
2004	254,345	36,810	2,104	4,503	12,088	79
2005	307,580	40,602	2,365	6,459	13,973	85
2006	378,168	36,781	2,038	3,890	14,635	66
2007	431,318	45,288	2,209	3,907	14,738	213
2008	485,813	48,590	2,514	5,567	15,526	5,988
2009	612,427	37,025	2,346	10,384	17,750	12,255
Florida						
1999	27,278,199	6,991,479	438,970	800,026	2,142,413	21,876
2000	28,724,112	7,917,411	510,913	754,034	2,257,344	31,725
2001	30,468,640	9,021,947	638,042	785,437	2,208,254	68,805
2002	32,058,437	10,562,009	674,762	891,003	2,707,490	28,531
2003	33,341,211	12,066,950	637,984	1,035,502	3,427,246	24,469
2004	35,002,091	13,133,979	638,687	1,513,472	4,257,091	32,508
2005	36,927,965	13,468,827	606,736	1,757,588	5,017,691	125,706
2006						

	38,902,637	12,949,112	587,297	1,345,339	5,158,256	32,480
2007	40,926,184	13,886,807	590,777	1,428,966	5,169,236	56,046
2008	43,015,330	14,888,481	672,411	1,964,851	7,625,052	90,900
2009	47,223,695	16,322,308	648,082	3,391,964	6,550,359	1,673,320

SS benefits = Social Security benefits
PAMC benefits = Public Assistance Medical Care benefits
Family assistance = FA
SNAP = Supplemental Nutrition Assistance Program
OIM = other income maintenance benefits
OTRIFG = other transfer receipts of individuals from governments

Appendix D

How the Index of Dependence on Government Is Constructed

After identifying the selected government programs that contribute to dependence, these expenditures were summed up for each of the five major categories listed in Table 2.5 on a yearly basis. The raw values for each program (i.e., the yearly expenditures for that program) are multiplied by their weight. The total of the weighted values is the index value for that year.

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A Dynamic Demand Driven, Supply Constrained Input Output Approach to Modeling Economic Impacts of Water Disruption Events

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Abstract. Drinking water supply systems are critical to the performance of regional economies. Small scale, aging infrastructure, limited budgets, and limited expertise combined with simple accidents make small regions more vulnerable to water disruptions than large metropolitan areas. Water disruptions result not only in direct costs, but also in important indirect economic losses. When a water disruption event occurs, there are not only changes in the final demand for goods and services but also in the supplies of inputs required by many industries. This study develops a dynamic demand driven input-output model with supply constraints that incorporate short run resilience strategies by both consumers and producers. By redefining the standard input-output system to be a partial equilibrium adjustment process, the system is able to accommodate supply constraints due to water disruption events, and include imbalances and adjustment effects generated from these constraints in continuous time. In this model resilience strategies in response to water disruption events are dynamic adjustments caused by very short run behavioral changes leading to direct and indirect economic consequences in the regional economy. The scenarios analyzed demonstrate the utility of the model when estimating the consequences of brief disruption events as well as the importance of individual resilience strategies, in particular the use of inventories and imported inputs to limit the impact of sales during the disruption event. The model will help local policy makers identify the most critical industries when considering precautionary measures and mitigation strategies to minimize economic losses. The model could also be used to assess alternative post-disaster reconstruction and recovery strategies when this type of event occurs.

Keywords: disaster impact model, dynamic input output model, continuous time, supply constraint, resilience.

Introduction

Drinking water supply systems are critical factors in the performance of regional economies. Limited scale, aging infrastructure, limit budgets and limited expertise combined with simple accidents make small regions more vulnerable to water disruptions. Short duration water disruption events are not evaluated as frequently as major disasters. However, they often generate significant economic losses especially given their much higher frequency. Events such as those that occurred in Walkerton, Ontario, Canada in 2000 provide evidence not only of the seriousness but also of the implications of water disruptions in small regions (Livernois, 2001).

This paper describes a dynamic demand driven input-output model with supply constraints that incorporates short run resilience strategies by both consumers and producers. . By redefining the standard input-output system to be a partial equilibrium adjustment process, the system is able to accommodate supply constraints due to water disruption events, and include imbalances and adjustment effects generated from these constraints in continuous time. In this model resilience strategies in response to water disruption events are dynamic adjustments caused by very short run behavioral changes leading to direct and indirect economic consequences on the regional economy. The utility of the model is demonstrated using a hypothetical small water disruption event. This model will help policy makers identify the most relevant industries when evaluating precautionary measures and mitigation strategies that minimize economic losses. The model can also be used to assess alternative post-disaster reconstruction and recovery strategies when this type of event occurs.

This paper is organized as follows: Section 2 reviews the research literature related to the economic impact of disasters events. The key features of the model are explained in Section 3. In Section 4, the conceptual framework as well as its application to the case of water disruption events is described. Data used and a scenario are presented in Sections 5 and 6, respectively. Conclusions follow in Section 7.

Literature Review

In recent years, significant progress has been made in improving models and analytic techniques for economic impact analysis of disasters (Okuyama, 2007). A review of the literature by Alva-Lizarraga & Johnson (2012) reveal that a wide range of recent studies including losses due to structural damages, restoration and remediation activities, opportunity costs of remediation, fire related losses, loss of life, shelter and displacement household needs, transportation related costs, property damage, neighbor effects, revenue losses to the utilities, and residential losses. Advance have been made in hazard risk estimation impacts of changes in behavioral attitudes such as those derived from social amplification of risk and, importantly the role of resiliency on depth and duration of economic consequences.

Analysts have employed various types of surveys, GIS applications, hazard loss estimation tools (e.g. HAZUS-MH), system flow programs (e.g. EPANET) and results from previous studies to estimate the direct economic consequences of disasters. Using these estimates of direct consequences, analysts then generate total economic loss estimates using input-output models, general equilibrium models, social accounting matrices , econometric models, econometric-input output models (e.g. REIM[1]), and econometric-computer general equilibrium models (e.g. REMI[2]). Some analysts have developed models that combine economic, engineering, hazard and/or spatial modules. However, the most common approaches rely on some sort of input-output model because of the tool's simplicity, its ability to reflect interdependencies between industries and the ease with which it can be adapted to include other non-economic aspects (Okuyama, 2007). Results from input-output models are considered upper bound estimates in contrast with results from computable general equilibrium models which are generally considered lower bounds (Okuyama, 2007).

Time and space dimensions are other important aspects when estimating economic losses. An explicit time dimension is included in models when the goal of the analysis is to understand the impacts of rebuilding activities, to account for aspects of production processes including production delays, transportation delays, or to explore the dynamic aspects of resilience behavior (Alva-Lizarraga & Johnson, 2012). Space is a relevant dimension because of

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[1] REIM is the regional econometric input output model originally developed by Israilevich et al. (1997)

[2] REMI is a computable general equilibrium econometric model developed by Regional Economic Models Inc.

the likelihood that neighboring areas will be affected by the changing demands of businesses directly affected by the disaster. Studies of this nature consider the location and network characteristics of infrastructure damages; the impacts on interregional economic flows and relationships; transportation related costs of the spatial distribution of direct, indirect and induced effects (Alva-Lizarraga & Johnson, 2012).

Regardless of the progress made in modeling water disruptions, Okuyama (2007) admonishes researchers to build models that more effectively include short run effects, spatial spillovers, behavioral changes and recovery and reconstruction strategies in order to effectively assess economic losses.

Characteristics of the Indirect Consequence Model

The proposed model addresses the first and the third points suggested by Okuyama (2007). It redefined the standard static input-output system in terms of partial equilibrium adjustment processes to incorporate short term effects and behavioral changes. To achieve this objective, aspects of continuous time economic models, resilience strategies and supply constraints are incorporated into the standard input-output model. The next section describes the modifications made in each of these areas.

Continuous Time Modeling

Most dynamic disaster models treat time as discrete units (e.g. the sequential interindustry model by Okuyama et al., 2004)[3]. However, this treatement of time leads to an number of modeling inflexibilities (Donaghy et al., 2007; Okuyama, 2007). For example, as is the case with any discrete dynamic model, discrete treatment of time can introduce instability and unrealistic dynamics due to inflexible and unrealistic lags (Johnson, 1979).

Continuous time models better manage the mismatch between the time intervals involved in water disruption events (days and hours) and the typical observation interval of the data used for modeling purposes (months and years) (Donaghy et al., 2007). The adequacy for the formulation of disequilibrium adjustment models, the treatment of the distributed lags, the use of differential instead of difference equations and the better treatment of stock and flow relationships are other advantages of continuous models (Gandolfo, 1993; Wymer, 1993). Furthermore, even though production adjustment decisions at the micro level can be made at discrete time intervals, their imperfect synchronization and possible overlap leads to potential imbalances in stocks and flows at the macro level that can be more easily managed with continuous models (Gandolfo, 1993; Wymer, 1993; Wymer, 2009).

In macroeconomic analyses, continuous time models have been used to investigate and analyze macroeconomic variables and to evaluate policy alternatives (Wymer, n.d). In these models, the system is described as a disequilibrium adjustment process. The existence of an equilibrium state does not presume the achievement of a steady state by the system (Saltari et al., 2011). However, these models usually reflect the transition from one disequilibrium point to another as the system evolves toward a new equilibrium following a change in one or

[3] The sequential interindustry model (SIM) is a discrete version of anticipatory and responsive production model decisions with inventories where technical coefficients are updated and final demand is completely exogenous. This model was originally proposed by Romanoff & Levine (1986) and adapted and used it by Okuyama et al. (2002; 2004) to model disaster events.

more exogenous variables (Wymer, n.d). Examples of these types of macroeconomic models included the work of Donaghy (1993; 1998) for the USA, Knight & Wymer (1978) for the UK, Sjoo (1993) for Sweden, Kirkpatrick (1987) for Germany and Gandolfo (1981) for Italy . While these models differ in many ways—their purpose, the definition of their equilibrium states, the behavioral relationships and whether they were described as a linear or non-linear adjustment process—they all use buffer mechanisms to absorb the short run differences between supply and demand. In all these models, the buffer is a stock (e.g. stock of goods or stock of money).

In the disaster literature, Donaghy et al. (2007) proposed a continuous time version of the regional econometric input output model (REIM) to model unexpected events. In particular, they model partial equilibrium adjustments of output, income, employment and other variables in REIM as a second order exponential lag. The model was considered an "exercise" but provides interesting insights about the dynamics of restoration activities following disaster events. However, this model did not incorporate aspects of resilience. In addition, like most econometric models, its system of equations requires large data sets that may be unavailable at the county or lower level.

By transforming the static input-output system into a system of partial equilibrium adjustment processes, the model becomes a continuous time model. The static equilibrium conditions for the input-output variables (production, sales, inventories and imported and local input expenditures) are replaced by equations of motion governed by Leontief input-output relationships.

Resilience

Resilience refers to the ability or capacity of a system to absorb or respond to damage or loss (Rose & Liao, 2005). Resiliency is generally an indicator of strength and flexibility of communities and firms (Bruneau et al., 2003) and in some cases, households. Resiliency is an important component in economic impact assessments of disaster events since it lowers the probability of failure and reduces negative consequences (Chang et al., 2002; Rose, 2009).

References to resilience strategies are often found in the literature on disasters. In particular, research has shown that some individuals and businesses do not "shut down" or even "scale down" but instead cope by adopting resilience strategies. For example, users of constrained infrastructure conserve water, use inputs from their inventories, substitute inputs, import inputs, reschedule production or temporarily stop the use of particular inputs (e.g. they may idle a particular machine or a particular group of workers) in order to maintain production at a level greater than what would otherwise be possible. Resilience strategies not only involve the use of less restricted production processes but also may involve changes in inputs, which is an important issue to consider when analyzing the economic consequences of this type of event since this leads to changes in the demand for the products of other sectors.

Most studies of disaster events have not completely accounted for the implications of these individual resilience strategies. A notable exception is the integration of resilience strategies into the economic impact analyses using Computable General Equilibrium Models by Rose and coauthors (Rose & Guha, 2004; Rose & Liao, 2005; Rose et al., 2007a, b; Chang et al., n.d.).

The model proposed here incorporates aspects of resilience through changes in the input-output coefficients of resilient industries and changes in final demand of resilient households. As a consequence new Leontief technical coefficients replace the standard coefficients during the length of the disruption event. Like the case of firms, new final demand of resilient households replaces the standard final demand during the same period.

Supply Constraints

Most studies of the economic implications of disaster events have employed standard demand driven input-output models. A weakness of this approach is that it assumes that the linkages between industries have not been affected by the water disruption and that the economic impacts are consequences of demand changes only. An example of a demand driven model is the Water Health and Economic Analysis Tool (WHEAT) model developed by the EPA (2010). In reality, when a water disruption event occurs backward linkages are affected. Models that include these changes usually do so by introducing "output" or "capacity" constraints with a transaction matrix rebalancing algorithm as in the HAZUS-MH model implemented by FEMA (2010). The rebalancing algorithm allows the model to reestablish imbalance between supply and demand by drawing down inventories or with import substitution.

Models known as mixed endogenous/exogenous input-output models (Miller & Blair, 2009) impose production constraints by exogenizing the constrained industry and endogenizing the final demand of that industry. This permits the model to avoid the overestimation of backward linked effects that typically occur with standard static input-output models. Examples of this application in demand driven input-output models includes the work of Johnson & Kulshreshtha (1982), Davis & Salkin (1984)[4], Petkovich & Ching (1978) and the recent work of Steinback (2004). While this technique has merit, its application can, in some cases, predict negative outputs.

A continuous dynamic input-output model with partial equilibrium adjustment processes avoids the need for an iterative solution algorithm and solves the problems frequently faced by mixed demand driven input-output models when supply constraints emerge.

The Model

A dynamic disequilibrium input-output model that assesses the economic implications of short-term water disruption events on production, local and imported purchase of inputs, inventories and sales for a small region is introduced. The model incorporates the static Leontief input-output model into partial equilibrium adjustment processes. The main relationships in the model are first order exponential lags. Supply constraints and resilience strategies are incorporated when water supply disruption events emerge.

Conceptual Framework

Consider an economy with "s" industries which purchase inputs from each other and combine these local inputs with imported inputs to produce outputs for sale to other industries and to satisfy final demand. In the standard static interindustry framework, production technologies are given by a coefficients matrix, A. Outputs are reported as the vector X. Each sectors outputs are consumed as intermediate inputs ($\sum_j a_{ij} X_j$) or as final demand (Y_i). Each sectors expenditures are composed of interme-

[4] Only the supply constraints derived from the purchase coefficients described by these authors corresponds to demand-driven supply-constrained models.

diate purchases ($\sum_i a_{ij} X_j$) and primary inputs - labor, and owners of capital- (W_j).

$$X_i = \sum_j a_{ij} X_j + Y_i$$
$$X_j = \sum_i a_{ij} X_j + W_j$$

In dynamic counterparts to this static model, industry outputs, final demand, payments to primary inputs as well as changes in inventory and capital purchases are functions of time. Furthermore, under static equilibrium conditions, current levels of these variables are equal to their equilibrium levels. However under dynamic disequilibrium conditions, current levels typically differ from equilibrium levels.

In the model proposed the dynamic variables are all time dependent with the exception of constants such as the inventory deterioration rate, the adjustment time rates and other parameters, the technical coefficients and the final demand. If any of these parameters change as a result of the shock being studied, they can be exogenously adjusted.

The model assumes that industries produce into and sell out of inventories. Thus inventories increase for industry i as a result of production ($P_i(t)$) and decrease with the rate of sales ($S_i(t)$)[5]. As in Donaghy (1993; 1998), Knight & Wymer (1978), Sjoo (1993), Kirkpatrick (1987) and Gandolfo (1981), inventory works as a buffer that absorbs differences between the rates of local production and sales. To account for the fact that some industries have inventories that deteriorate very fast (restaurants and certain food manufacturers) or have no inventories at all (services), the model assumes that inventories also decrease according to an industry-specific deterioration rate ϑ_i, assumed to be constant between 0 and 1. This is consistent with the literature of production inventory models (Benhadid et al., 2008; Liu, 2009). It is also assumed that the deterioration rates apply to the difference between total production and sales ($P_i(t) - S_i(t)$):

(1) $$\frac{dN_i(t)}{dt} = P_i(t) - S_i(t) - \vartheta_i * \left(P_i(t) - S_i(t)\right) \quad for\ i = 1 \ldots s$$

The relationship between industry output and the purchase of inputs is referred to as the industry's production function. As in input-output models, the production technology is assumed to be a Leontief technology production function which is a linear function of intermediate (local and imported) input commodities and valued added inputs.

Equation 2 describes the disposition of production ($P_i(t)$) between the purchase of inputs and value added. It states that industrial production is the sum of the aggregated local intermediate inputs purchased by the industry and valued added ($LI_i(t)$) and the imported intermediate inputs ($MI_i(t)$) purchased by the industry:

(2) $$P_i(t) = LI_i(t) + MI_i(t) \quad for\ i = 1 \ldots s$$

Planned aggregated local intermediate inputs and valued added ($DLI_i\ (t)$) adjust to their equilibrium level according to an adjust-

[5] The traditional square input-output model is balanced in the sense that the value of sector output is exactly equal to sector expenditures (including profits, losses, and savings or borrowing). The IO table is traditionally arranged as a square matrix in which a sector's sales to other sectors and to final demand, are arranged as rows (indicated by i) and its purchases from other sectors and profits and capital account transfers are arranged as columns (indicated by j). Since sales and expenditures are equal, "i" will be used to indicate the totals by industry whether sales or expenditures.

ment rate γ_{1_i}. This equilibrium value is defined as the planned output being produced using local inputs, represented as the product of the share of planned output $DX_i(t)$ that is fulfilled by local inputs (ρ_i).

(3) $$\frac{dDLI_i(t)}{dt} = \gamma_{1_i}\left(\rho_i * DX_i(t) - DLI_i(t)\right) \quad for\ i = 1 \ldots s$$

As for the case of planned local inputs, planned imported intermediate inputs ($DMI_i(t)$) also adjust to their planned equilibrium state at an adjustment rate γ_{2_i}. The equilibrium state is defined as the share of planned output $DX_i(t)$ that is fulfilled by imported inputs $(1-\rho_i)$.

(4) $$\frac{dDMI_i(t)}{dt} = \gamma_{2_i}((1-\rho_i) * DX_i(t) - DMI_i(t)) \quad for\ i = 1 \ldots s$$

Planned output $DX_i(t)$ is the sum of planned sales ($DS_i(t)$) and imbalance in inventory ($DN_i(t)$):

(5) $$DX_i(t) = DS_i(t) + DN_i(t) \quad for\ i = 1 \ldots s$$

Planned sales are the sum of intermediate demand $\left(ID_i(t)\right)$ and final demand (Y_i)

(6) $$DS_i(t) = ID_i(t) + Y_i \quad for\ i = 1 \ldots s$$

Intermediate demand adjusts to its equilibrium state according to an adjustment rate γ_{3_i}. This equilibrium value is defined as the total demand for inputs required for production $P_j(t)$.

(7) $$ID_i(t) = \gamma_{3_i}(\sum_{j=1}^{s} a_{ij} * P_j(t) - ID_i(t)) \quad for\ i = 1 \ldots s$$

As in Johnson (1993), Donaghy (1993; 1998), Knight & Wymer (1978), Sjoo (1993) and Gandolfo (1981), the current imbalance in inventories is the difference between their equilibrium ($\alpha_i * S_i(t)$) and current levels. The equilibrium inventories are the product of the sales ($S_i(t)$) and the planned ratio of inventories to sales (α_i).

(8) $$DN_i(t) = \alpha_i * S_i(t) - N_i(t) \quad for\ i = 1 \ldots s$$

Sales are equal to planned sales (DS_i (t)) if inventories are sufficient to meet sales. Otherwise sales are limited to the production ($P_i(t)$)

(9) $$S_i(t) = \begin{cases} DS_i(t) & if\ N_i(t) > 0 \\ P_i(t) & if\ N_i(t) = 0 \end{cases} \quad for\ i = 1 \ldots s$$

Production is constrained by the supply of inputs. Constrained production ($CP_i(t)$) occurs when one or more inputs required for the production of goods and services of industry j ($PU_{ij}(t)$) are restricted to an amount ($PU_{ij}^*(t)$) which is less than that required ($PU_{ij}(t)$). Purchases of the ith good by industry j ($PU_{ij}(t)$) could come from local or imported sources. According to the Leontief production function, the level of production is constrained to the level possible with the most limiting input:

(10) $$CP_j(t) = Min\{\frac{PU_{1j}(t)}{a_{1j}}, \frac{PU_{2j}^*(t)}{a_{2j}}, \ldots \frac{PU_{sj}(t)}{a_{sj}}\} \quad for\ j = 1 \ldots s$$

$$PU_{ij}(t) = \delta_i * a_{ij} * DX_i(t) \quad for\ i,j = 1 \ldots s$$

where δ_i is the proportional restriction on local input from industry i and a_{ij} are Leontief technical coefficients.

During the disruption event, only purchases of local inputs are constrained.

(11) $CLP_i(t) = \beta_i * CP_i(t)$
$for\ i = 1 \ldots s$

where β_i is the proportion of the ith local input restricted. It is assumed that β_i is equal to the proportion of expenditures fulfilled by local inputs (ρ_i) found in equation (3).

Imported inputs can fulfill ε_i percent of the imbalance between the local input expenditures and the local input constraint ($DLI_i(t) - CLP_i(t)$) when purchase of local inputs is restricted and for those industries that hold inventories. The parameter ε_i is an empirically determined resilience characteristic. This dynamics occurs during the disruption event ($t_1 \leq t \leq t_2$).

With the constraint imposed on local inputs and the possibility of substituting locally for imported inputs, local inputs and imported inputs are represented by:

(12) $$LI_i(t) = \begin{cases} Min\{DLI_i(t), CLP_i(t)\} & \text{if } t_1 \leq t \leq t_2 \\ DLI_i(t) & \text{if } t > t_2 \text{ or } t < t_1 \end{cases} \quad \text{for } i = 1 \ldots s$$

(13) $$MI_i(t) = \begin{cases} MI_i(t) + \varepsilon_i * (LI_i(t) - CLP_i(t)) & \text{if } t_1 \leq t \leq t_2 \\ MI_i(t) & \text{if } t > t_2 \text{ or } t < t_1 \end{cases} \quad \text{for } i = 1 \ldots s$$

Production, sales, and local and imported input expenditures, and inventories, the restriction in production, and their planned values are always positive:

(14) $N_i(t), P_i(t), S_i(t), X_i(t), MI_i(t),$
$LI_i(t), DX_i(t), DS_i(t), CLP_i(t),$
$DLI_i(t), DMI_i(t), DN_i(t) \geq 0$

Several key assumptions are made in order to operationalize this model. First, given the need to model short-term disruptions, the implications of investment decisions on output are omitted. This assumption is adequate when modeling short-term events. However, if a disruption event induces serious damages to output capacity, it would be more appropriate to incorporate the dynamics of investment decisions using an acceleration modeling approach. Second, it is assumed that industries do not face capacity constraints other than those caused by the water disruption. Because of the short-term nature of these scenarios large increases in exogenous final demand are not likely. Third, production is constrained by exogenous events (such as disruption events) that limit the ability of firms to produce. Fourth, the focus of this research is on the dynamics of sales and production and not on changes in production processes other than those related to resiliency. Finally, deviations between production, expenditures of local and imported inputs, and sales are adjusted through changes in quantities and not prices. Since the purpose of this model is for short-term water disruption events, prices are unlikely to change[6]. This assumption is common in assessments of disaster events (e.g. see Harrington et al., 1991; Donaghy et al., 2007; and HAZUS by U.S. Federal Emergency Management Agency, 2010).

Static Equilibrium States

If equilibrium conditions are achieved, local and imported purchases, production, sales, and inventories reach their static Leontief equilibrium state:

(15) $S_i(t) = P_i(t)$

[6] During and following some disasters, 'gouging' is reported. This practice of raising prices during disaster-induced shortages is discouraged and sometimes made illegal.

(16) $S_i(t) = \sum_{j=1}^{s} a_{ij} * P_j(t) + Y_i$

(17) $MI_i(t) = (1 - \rho_i) * P_i(t)$

(18) $LI_i(t) = \rho_i * P_i(t)$

(19) $N_i(t) = \alpha_i * P_i(t)$

where sales, imported and local inputs and production corresponds to flows (in monetary units per year). Inventories represent the stock of goods and services (in monetary units). At equilibrium, the rate of sales is equal to the rate of production (15). Also, local and imported inputs (equations 17 and 18, respectively) are equal to their equilibrium values. Since these variables have reached their equilibrium values, change of inventories is also equal to zero. That makes the level of inventories equal to their equilibrium levels (19).

Equations (1) to (13) were translated into the system dynamics software, Stella[7]. System dynamics is a holistic approach in which models are built with differential and partial differential equations, feedback effects, non-linear relationships and lags of various lengths to describe a system in the process of change (Scholl, 2001; Meyer et al., 2009). One advantage of the system dynamics modeling approach is its emphasis on disequilibrium rather than equilibrium processes. This characteristic is particularly appealing given the requirements of the proposed model.

Resilience and Other Individual Strategies

When a temporary reduction of public water supply (W) occurs, businesses must choose between two general strategies: temporarily ceasing operations or coping with the event to maintain production at some level. When businesses choose the first option, they are usually unable to stop purchasing certain types of inputs. These inputs are "fixed" in the sense that they must be paid in the short term. Examples of these short-term fixed inputs are rent, insurance, contracted services. Other businesses will respond by coping, e.g. temporarily substituting for, or limiting the use of, products that require public water in order to continue production. Both options involve reduced profits. These strategies alter the use matrix (absorption coefficients) in the input-output model. As a consequence new input-output coefficients (from $a0_{ij}$ to ar_{ij}) will be available during the duration of the disruption event:

[7] STELLA is a system dynamics software especially designed for multidisciplinary group model building (http://www.iseesystems.com/).

(20) $$a_{ij} = a_{ij}(t) = \begin{cases} ar_{ij} & if\ t_1 \leq t \leq t_2 \\ a0_{ij} & if\ t > t_2\ or\ t < t_1 \end{cases}$$

where ar_{ij} the input-output coefficient with resilient strategies and $a0_{ij}$ is the efficient input-output coefficients in the absence of the disruption event.

Since the input-output coefficients change during the disruption event, the share of planned output fulfilled by local inputs (ρ_i) will be also be changed:

(21) $$\rho_i = \rho_i(t) = \begin{cases} \rho r_i & if\ t_1 \leq t \leq t_2 \\ \rho 0_i & if\ t > t_2\ or\ t < t_1 \end{cases}$$

Households choose from a range of strategies in order to cope with the disruption. Unlike businesses, households cannot temporarily "shut down". They can turn to the market to purchase substitute "household" good and services to fulfill their needs. These alternatives will imply changes in expenditure patterns including the level of final use imports. The altered expenditure patterns induce changes in final demand. Yr_i and Yo_i correspond to final demand with and without the water disruption respectively.

(22) $$Y_i = Y_i(t) = \begin{cases} Yr_i & if\ t_1 \leq t \leq t_2 \\ Yo_i & if\ t > t_2\ or\ t < t_1 \end{cases}$$

The use of inventories is modeled through adjustment equations (1).

Finally, the substitution of local inputs for imported inputs is modeled through equations (12) and (13).

Data

Data on the use matrix, valued added, technical coefficients and output levels are obtained from IMPLAN system V3 as developed by MIG (2012). A hypothetical disruption event in a small Kentucky community is modeled below.

For demonstration purposes, the adjustment rates ($\gamma_{1_i}, \gamma_{2_i}, \gamma_{3_i}$) are not estimated in this study. Following Carlson (1973) adjustment rates of 5 were used. This value has also been applied in the regional dynamic input output models developed by Johnson (1979, 1983; 1985; 1986; 1993).

Information from resilient and other strategies were obtained from a recent survey of water disruption events conducted by University of Missouri-Columbia researchers (Jensen et al., 2011). For demonstration purposes, we model the consequences of using substitute products (e.g. use of disposable rather than glass containers), purchase of bottled water and closure of businesses. These expenditure changes were introduced into the IMPLAN V3 as new gross absorption coefficients in order to obtain new adjusted technical coefficients. Other resilience strategies such as the use of inventories and imported inputs were modeled as dynamic adjustment processes.

The percentage of inputs imported to fulfill the imbalance between the input requirements and the local input constraint $(LI_i(t) - CLP_i(t))$ will be assumed to be 5 percentage points higher than their current levels $(1 - \rho_i)$. This assumption follows suggestions from the HAZUS-MH Earthquake model (U.S. Federal Emergency Management Agency, 2010).

Changes in household expenditures patterns included conservation, purchase of bottled water, boiling water, eating more at restaurants and going to the doctor to treat illness related to water contamination. Additional assumptions and information were obtained from previous studies (e.g. see for example Harrington et al., 1991) and official statistics (e.g. U.S. Geological Survey [USGS], 2005).

Using IMPLAN, the new and original technical coefficients by industry were aggregated to 11 industries. These industries include: Agriculture (1), Mining (2), Utilities (3), Construction (4), Manufacturing (5), Wholesale Trade (6), Transportation and Warehousing (7), Retail Trade (8), Professional Services (9), Education, Health, Recreation Services (10) and Government and Non NAICS (11). Only the agriculture, mining and manufacturing are assumed to hold inventories with desired ratios of 1.

Simulation Results

The simulations have two purposes. The first is to show the ability of the model to incorporate short-term restrictions in production. The second is to demonstrate the relevance that resilience strategies, especially, import substitution and sales from inventories have on the direct and indirect economic consequences when a short run disruption event in the water industry emerges.

The water restriction scenario is s "water outage". In this scenario, the order imposes a 20% constraint on the water utility for 5 days which also restricts the ability to water users by the same amount. The event is assumed to occur at month 2.5 (t_1=0.1) and continues until after the sixth day (t_2=0.114) at which time the utility restores production back to 100%. The restriction on the water utility is introduced by reducing total sales and expenditures (row and column) in the Utility Industry by 20% during the disruption period. During this period, conservation, and substitution resilience strategies and other activities (ar_{ij}, Yr_i , ρr_i) are the only expenditure patterns available[8]. Industries also face the choice of either replacing local with imported inputs in order to maintain production or to reduce their production levels in proportion to the reduction in the water capacity. Once the disruption is over, businesses and consumers return to their previous expenditure patterns (ao_{ij}, Yo_i, $\rho 0_i$). No further changes are imposed.

Simulations were run for a period of one year[9]. To demonstrate the importance of *only* imported input substitution and sales from inventories as resilience strategies, three scenarios are modeled: no imports or inventories strategies implemented ("No Imports / Inventories"), imports and use of inventories strategies ("Imports/Inventories"), imported inputs but not use of inventories ("Only imports"), and only use of inventories but not imported inputs ("Only inventories").

Table 1 shows the results of these simulations for the region. In the absence of imported inputs and inventories ("No Inventories/Imports"), annual rate of sales and production will be reduced by 20% from their baseline levels by the end of the disruption. When these resilience strategies are available ("Inventories/Imports") the impact on the annual rate of sales due to reductions in the annual rate of production is only 6.37%. Furthermore, by re-

[8] Other combinations are also possible. For example, industries and households that have not been affected by the disruption event operate under the expenditure patterns previously to the disruption event while those affected operate with the resilient expenditure patterns. For the scenario modeled, it was assumed that all the industries operate with the same expenditure patterns.

[9] The dt (increment in the numerical integration algorithm) was 1/1000th of a year.

placing local with imported inputs up to 12% of their baseline levels, annual rate of production is reduced by less than 7.91%. The relative consequences of utilizing imported inputs compared to reliance on inventories can be determined by comparing the scenarios “Only Imports” with “Only Inventories”. Annual rate of sales declined only 7.9% in the imported inputs only scenario and 11.3% approximately in the inventories only scenario. Annual rate of production decreases by 7.9% and 20% respectively. These results indicate that while inventories acts as a buffer for sales, substitution for additional imported inputs does the same for production. In the absence of inventories, sales are limited to what is able to be produced. Finally, in the absence of imports, reductions in production reduce the demand for goods and services and hence sales.

By the end of the year, variables are still recovering to their equilibrium states in particular in the scenarios where the recuperation of inventories induces the increase of sales and production. However, their difference relative to the equilibrium states (baseline values) are very small.

Table of Contents

Table 1: Changes in the Annual Rate of Production, Sales, Local Inputs and Imported Inputs, and Use of Inventories by the End of the Disruption and the End of the Year (in Percentage relative to the Baseline)

Scenarios	Production	Sales	Local Inputs	Im-ported Inputs	Use of Inventories
By the End of the Disruption					
Inventories/Imports	-7.91%	-6.37%	-20.01%	11.93%	-3.43%
Only Inventories	-20.00%	-11.13%	-20.00%		-19.90%
Only Imports	-7.91%	-7.91%	-20.01%	11.93%	
No inventories/Imports	-20.00%	-20.00%	-20.00%		
By the End of the Year					
Inventories/Imports	0.01%	-0.01%	0.00%	0.01%	0.03%
Only Inventories	0.06%	0.00%	0.06%		0.001544
Only Imports	-0.01%	-0.01%	-0.01%	-0.01%	
No inventories/Imports	-0.02%	-0.02%	-0.02%		

Industries are affected differently depending on the availability and importance of imported inputs and inventories. Figures 1 to 3 show the behavior of annual rate of production, sales, imported inputs and local inputs, and inventories for the region and selected industries during the disruption event for the scenario "Inventories/Imports". As shown in figure 2, inventories and imported inputs in the manufacturing industry fulfill the additional demand incurred for this industry for the first three days of the disruption period (t=[0.1,0.108]). This additional demand is driven by the resilience strategies of other industries and households including the use of inventories. As a result, the industry is able to sell more during this start period. For the last two days of the disruption period (t=[0.108,0.114]), the reduction in demand from the other sectors induced by lower production eventually reduces the local sales of this sector as well.

As observed in figure 3, this behavior contrasts with the services industry which, in the absence of inventories, is only able to import more in order to fulfill the reduced demand for its goods and services. The dynamics of the interrelated industries drives the behavior of sales, production, inventories, imported inputs and local inputs for the region as shown in Figure 1.

Figure 1: Annual Rate of Production, Sales, Imported Inputs and Local Inputs, and Inventories for the Region during the Disruption Event for the "Inventories/Imports" Scenario

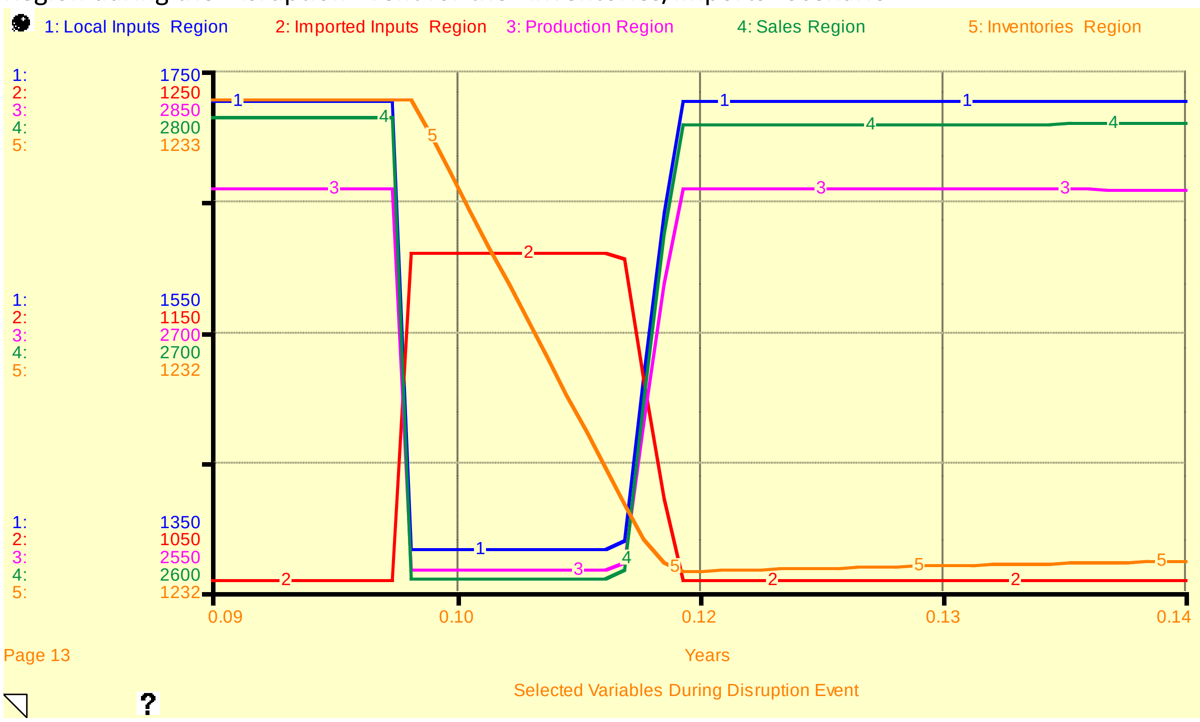


Figure 2: Annual Rate of Production, Sales, Imported Inputs and Local Inputs, and Inventories for the Manufacture Industry during the Disruption Event for the "Inventories/Imports" Scenario

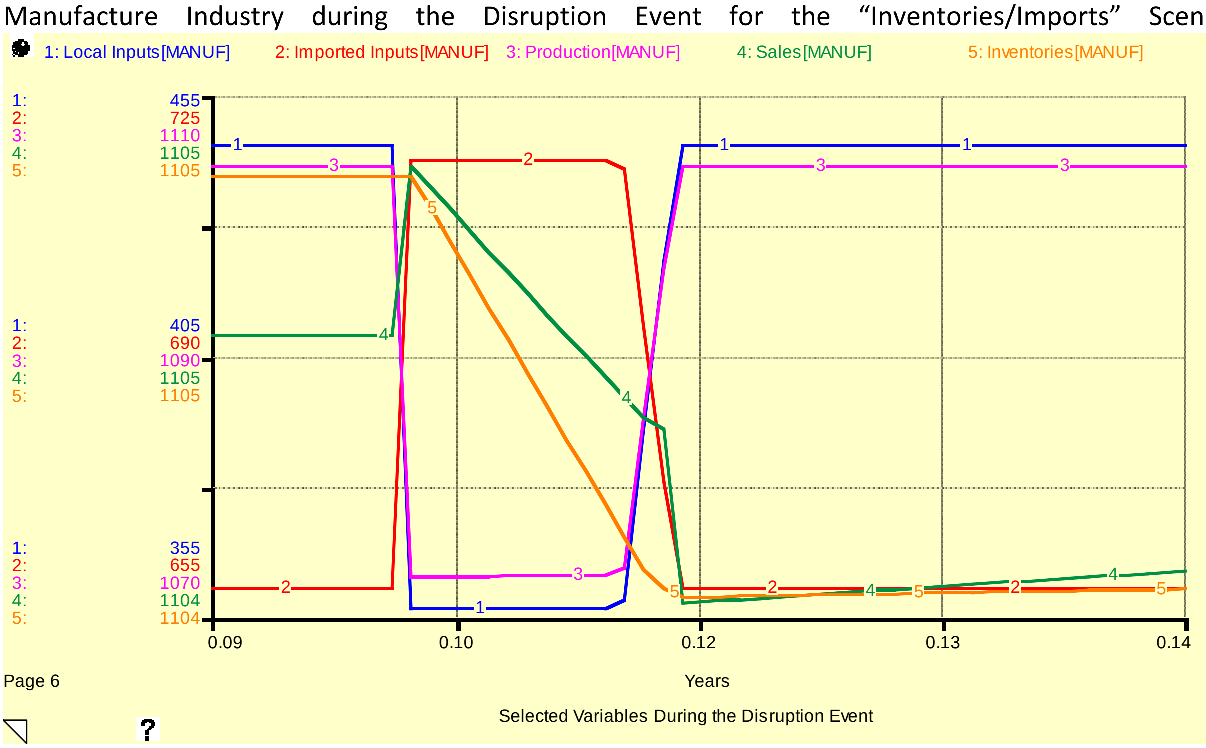
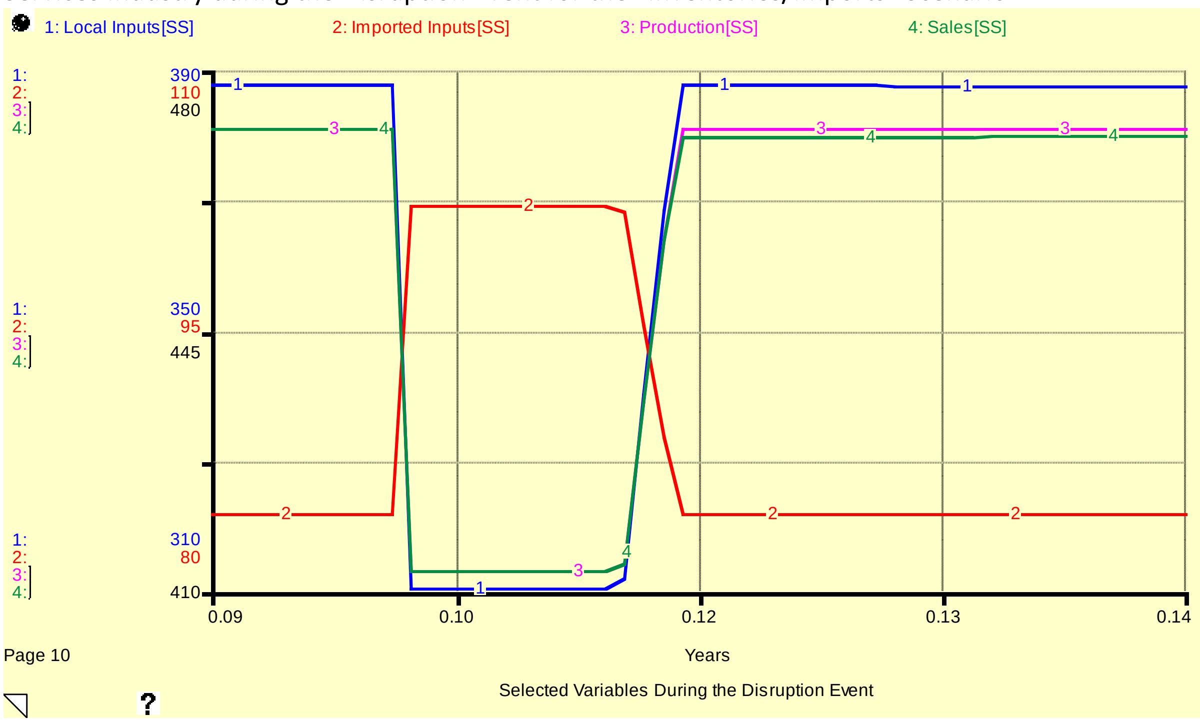


Figure 3: Annual Rate of Production, Sales, Imported Inputs and Local Inputs, and Inventories for the Services Industry during the Disruption Event for the "Inventories/Imports" Scenario



Conclusions

The purpose of this paper was to describe the continuous time dynamic, demand driven input-output model with supply constraints and short run resilience strategies used to model water disruption events. The continuous time reformulation of the input-output system in terms of partial equilibrium adjustment processes facilitates the short-run supply constraints. The scenarios modeled not only demonstrate the different dynamics that occur during and after the disruption event for sales, inventories, imported inputs and production. Depending on the possibility of importing inputs and the level of inventories available at the industry level together with other resilience strategies employed by other industries, the economic losses in terms of sales or production show quite different dynamics. As more data become available from on-going surveys, more resilience strategies can be modeled. The surveys will also permit estimating more precise parameters.

There are a number of ways in which the model could be extended to give it additional features. In the area of water contamination, health impacts are particularly important since they affect the productivity of workers with a chain of reactions in production as well consumption. Second, spatial patterns of impacts are important because of the likelihood that neighboring areas will be affected by the changing demands of local businesses directly affected by the disruption. The transformation of the model into an interregional dynamic input-output model could facilitate this procedure. However, the lack of available adjustment rates could limit this application. Finally, system flow programs for drinking water such as EPANET and TEVA-SPOT could be used in order to have a more accurate picture not only of the restrictions in production due to water disruption events but also the direct and indirect economic implications of the recovery activities.

Once the model has been fully tested and is available for release, it will help local policy makers identify the most critical industries when planning precautionary measures and mitigation strategies. The model could also be used to assess alternative post-disaster reconstruction and recovery strategies.

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