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Abstract

In 2014, Egypt started its national road project. This project is one of the greatest achievements in the history of Egyptian roads, and perhaps even all infrastructures. It is designed to connect the country's governorates through a 30% expansion of the existing 23,500 km network of roads. Its costs are currently estimated at $9.8 billion. There are now about two-thirds of the National Roads Project plans; another 1,300 km is still under construction. Another 1,200 km will be built in the near future. The project has enhanced accessibility across the country enriching the opportunity for further expansion into industrial, agricultural and urban areas. Measuring the project's economic impacts would emphasize the project's importance and allow for better targeting of new road projects. In this paper, we explore how the National Road Project likely changed the country's economy at both the national and regional levels. We do this by applying the Computable Spatial General Equilibrium (SCGE) model in Egypt. We found that the project revitalized the national economy by engaging deeply in some of Egypt's least developed governorates. The increased accessibility brought by the corridor has translated into positive efficiency gains at the national and regional levels. The model allows for exploration of the areas most affected by the project and thus could assist planners in allocating infrastructure investments.

JEL Classification: H1, O1

Keywords: Infrastructure, Development, Egypt

ملخص

بدأت مصر عام 2014 مشروعها الوطني للطرق، ويعد هذا المشروع من أعظم الإنجازات في تاريخ الطرق المصرية، وربما حتى جميع البنى التحتية. وهي مصممة لربط محافظات البلاد من خلال توسيع شبكة الطرق الحالية التي يبلغ طولها 23,500 كيلومتر بنسبة 300 كيلومتر. وتقدر تكاليفها حاليا بنحو 9.8 مليار دولار. وهناك الآن نحو ثلثي خطط المشروع الوطني للطرق؛ ولا يزال هناك 1300 كيلومتر آخر قيد الإنشاء. وسيتم بناء 1200 كيلومتر أخرى في المستقبل القريب. وقد عزز المشروع إمكانية الوصول في جميع أنحاء البلاد مما أثرى الفرصة لمزيد من التوسع في المناطق الصناعية والزراعية والحضرية. ومن شأن قياس الآثار الاقتصادية للمشروع أن يؤكد على أهمية المشروع ويسمح باستهداف أفضل لمشاريع الطرق الجديدة. في هذه الورقة ، نستكشف كيف من المحتمل أن يغير مشروع الطرق الوطني اقتصاد البلاد على الصعيدين الوطني والإقليمي. نقوم بذلك من خلال تطبيق نموذج التوازن العام المكاني القابل للحساب (SCGE) في مصر. وجدنا أن المشروع أعاد تنشيط الاقتصاد الوطني من خلال الانخراط بعمق في بعض المحافظات الأقل نموا في مصر. وقد ترجمت زيادة إمكانية الوصول التي أتاحها الممر إلى مكاسب إيجابية في الكفاءة على الصعيدين الوطني والإقليمي. ويسمح النموذج باستكشاف المناطق الأكثر تضررا من المشروع، وبالتالي يمكن أن يساعد المخططين في تخصيص استثمارات في البنية التحتية.

1. Introduction

Egypt's growing population and dynamic economy have stretched the nation's existing infrastructure over past decades. Moreover, motor vehicles remain the nation's transport mode of choice, creating a particular need for more and better roadways. In response, Egypt's government has spearheaded significant investment in the road system to help its people cope with future traffic that is being forecast (Oxford Business Group, 2021). According to the Ministry of Transportation, more than 50% of the total investments in the transport sector from 2014 to 2021 (about 225 billion), were allocated to roads and bridges projects. The investments are reflected in Egypt's "Vision 2030" in which the major collection of transportation improvements is labeled "the National Road Project". Other modes of transport recently have started to take increasing attention starting 2021 as reflected in the fiscal year 2021/2022 budget. The National Tunnels Authority alone has about LE 113 billion (about 46% of the total investments in the transport sector) directed to implement the two fast electric train projects, another 27 billion to be invested in the railways field, whereas 26 billion has been allocated to the roads and bridges projects.

The National Roads Project is designed to increase the capacity of the transport sector and boost the nation's international and regional transport volumes. Specifically, it designed to decongest the crowded and narrow Nile Valley by diverting long-distance traffic through and building new towns in less densely inhabited areas in the back desert of cities with high population density. Among them are the New Administrative Capital, New Alamein, New Mansoura, East Port Said, Nasser City in western Asyut and the New Ismailia city. It is hoped the project will enable wealth by engaging mining, tourism, and other industry in these peripheral areas. In so doing, it should enhance productivity and production in agriculturally rich hinterlands. This latter is especially the case of the national reclamation project of 1.5 million acres.

The importance of the National Road Project can be highlighted by estimating the magnitude of the project economic impacts on Egypt's economy. Such work can show how the project affected the economic development of specific locales as well as regions in which they are located. We employ a modeling framework that would enhance the Egyptian Government's analytical capabilities in fostering sustainable regional growth in Egypt (Haddad et al., 2016; Elshhawany, Haddad, and Lahr, 2017). The model enables rigorous analysis for use by decision makers.

We investigate the impact of The National Road Project as built to date, on Egypt's economy at both national and regional level using an ICGE model of Egypt that is specifically designed to estimate the impacts of road projects.

2. The National Road Project

Since 2014, Egypt has been implementing a large, transportation infrastructure plan—the National Road Project (see Figure 1). This project is one of the largest yet in the modern Egypt's transportation history. It will enhance the road transportation network from its current 23,500 kilometers to around 30,500 kilometers at a total cost about US$9.79 billion. The project has three phases. The first includes 12 new roads with a total length 3,400 km. Four more roads comprise phase two, which adds about 1280 km as well as resurfacing and widening 2,500 km of existing roadways. Phase three, the construction of which is currently underway, adds six new roads with a total length of 1300 km. In essence about 4,580 of the 7,000 kilometers planned as the National Roads Project are already being used (AkbarElyoum, 2021). The most important roads are shown in Figure 1: the Upper Egypt/Red Sea Road (180 km), the Shobra/Banha Road (40km), the Regional Ring Road (400 km), the Elgalala Road (82 km), and the Elfarafra/Ain Dala Road (90km).

Figure 1. The National Road Project

Source: The Ministry of Transport (2018).

3. Research Approach

In terms of road infrastructure, Egypt ranked 118th among world nations according to the World Economic Forum (2014) when the project was launched. By 2019, it had climbed to 28th place (Ahramonline, 2021). Also, the number of road accidents in Egypt fell by around 30 percent, from 14,403 in 2014 to 9,992 in 2019 (CAPMAS, 2020). While this is all excellent news, the economic impacts to Egypt are also important to measure as improving them motivated the project.

Transportation planners and decision makers have long been concerned with how transportation investments and services shape economic development. In recent years, as projects became larger and more complex, and as public participation has become more common, economic development impacts have played a bigger role in project evaluation and prioritization (Gkritza, 2008).

The potential ability of transport infrastructure investments to produce transport benefits depends on the travel time reductions and accessibility. The debate is over whether there are additional benefits from these investments, generically referred to as economic development benefits and how to measure them. The term economic development and economic growth cover the long-term increase in economic activity which can be attributed to the specific investment (Banister and Berechman, 2001).

A wide range of methods have been deployed to measure these economic impacts. There are qualitative surveys, detailed market studies, and comprehensive economic simulation models to list just a few. The primary economic assessment methods considered include: Social Cost Benefit Analysis (SCBA), Input-Output Analysis (I-O), and Computable General Equilibrium models (CGE). SCGE modeling of transport began to spread globally throughout the 2000s, with many models differing in their methods of simulating the transport sector (Edward et al,2018).

In these models, transport was treated as a tradable material input, created with a production technology similar to other sectors. This assumption could be justified at the macroeconomic level of analysis which did not rely on a concept of space. As CGE models were extended into the spatial dimension during the 1980s, prices could be differentiated by region (Robson et al, 2018).

The general equilibrium approach treats the economy as a system of many interrelated markets which the equilibrium of all variables must be determined simultaneously. Any perturbation of the economic environment can be evaluated by recomputing the new set of endogenous variables in the economy. This methodological feature of general equilibrium analysis attracted many researchers to develop its applied dimension. The desire to convert general equilibrium theory into a practical tool for the evaluation of economic policy motivated the construction of algorithms for computing solutions to numerically specified general equilibrium models (Haddad et al, 2009).

In order to evaluate a transport project there is a need for both CGE and transport models. The transport model evaluates the impact of the project on travel time or cost and the CGE model evaluates the impact of the change in travel time or cost on the entire economy (shahriari et al, 2021). The stream of research linking CGE models to transportation networks include, among others Buckley (1992), Bröcker (1998), Bröcker and Schneider (2002), Kim and Hewings (2003), Kim, Hewings, and Hong (2004), Haddad and Hewings (2005), Kim, Kim, and Hewings (2011), NCFRP (2011), Haddad et al. (2011, 2016), and Sakamoto (2012), Elshahawany, Haddad and Lahr (2017), Shahriari, (2021).

We base our ex-post spatial impacts estimates of the Project on a spatial computable general equilibrium model (SCGE) model for Egypt's economy (Haddad et al., 2016; Elshahawany, Haddad, and Lahr, 2017). An important feature of this model is that we explicitly estimate the value of freight by origin–destination pair, given national transportation margins. That is, the model roughly accounts for the cost structure of freight by traded commodity. We examine the estimated trade flows before and after the National Road Project. So it is not the trade estimates themselves that matters, but rather how we model estimates of the change in trade.

A key issue in such regional modeling is data availability, however. Discussions on the creation of databases that underlie applications are the subject of a few articles. For developing countries, data limitations are especially pronounced at the regional level. The lack of data requires applying some theoretical assumptions and developing algorithms to create the regional data in part by spatially disaggregating nation-level data.

The ICGE database requires detailed sectoral and regional information about the Egyptian economy. An interregional input-output system for Egypt is used in the process of calibration of the structural coefficients of the model. The construction and improvement of such database are part of an initiative involving researchers from the Regional and Urban Economics Lab at the University of São Paulo (NEREUS), the Rutgers Economic Advisory Service (R/ECON) at the Edward J. Bloustein School of Planning and Public Policy at Rutgers University, and the Economic Department at the Faculty of Commerce at the Zagazig University.

A fully specified interregional input-output database has been estimated under conditions of limited information, we have applied some hypotheses and procedures to develop the interregional input-output matrix for Egypt. We use data of the national accounts and regional statistics provided by the Central Agency for Public Mobilization and Statistics (CAPMAS).

The development of the input-output system relied basically on the following databases: (i) aggregate input-output table for year at basic prices; (ii) Household Income, Expenditure, and Consumption Survey, HIECS; (iii) sectoral employment data, by governorate; (iv) other socioeconomic indicators by governorate; and (v) estimated travel time among governorates' capitals using GIS information of Egypt's road network.

The modeling structure used in this paper is the manner in an integrated geo-coded transportation network for Egypt with the SCGE model[1]. Thus, if one wants to simulate changes in the network that might affect relative accessibility, an *ex post* transportation cost matrix can be calculated in addition to the pre-existing ex ante rendition. These, in turn, can then be transformed by the SCGE model via transportation cost functions. This transformation includes two stages: model calibration and simulation.

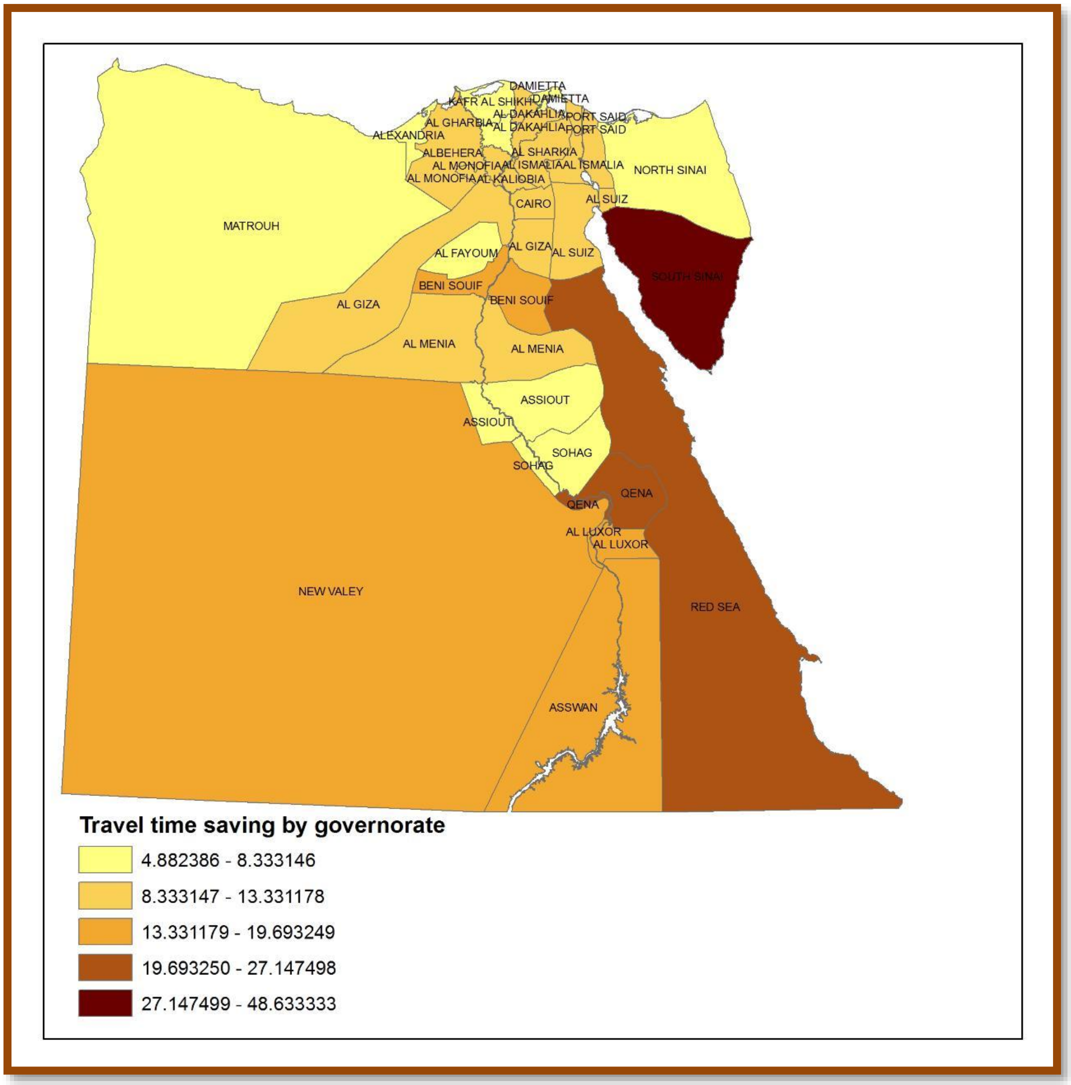
4. Travel Time Savings Induced by the National Road Project

Roadways are built and maintained to improve an economy's productivity, and not for the sake of their construction effort, which can be substantial in some localities. That is, the principal benefit of transportation projects is that they reduce transportation times. To calculate the travel time savings induced by the National Road Project as the difference between travel time before and after the project put in place, a detailed national-level GIS road network data for 2013 (before the initiation of the National Road project) was generously provided by the Egyptian Central Agency for Public Mobilization and Statistics (CAPMAS). We merged this database with information on specific technical road attributes to estimate of the maximum speed of each road in the network so that, when combined with road length information, we could estimate travel times of every single road and, hence, network link and path. To drive travel time estimates after the construction of the project, we use Google maps which provide the most recent information of . We did so by examining times on minimum impedance paths, in terms of hours, across the prime cities of Egypt's governorates.

Figure 2 shows the aggregate time savings by governorate obtained after the construction of phase 1 and phase 2 and part of phase 3. Total travel time saving across all governorates is about 350 hours between every governorate and the other 26. Most of these travel-time savings accrue to poorer peripheral governorates that are most distant most from Egypt's urban core. To trace economic benefits from travel-time reductions as effected by the National Road Project, we next highlight some of the new roads and their effects on travel time among the governorates.

[1] More information about the procedures to develop the mentioned SCGE model in Haddad et al, (2016).

Figure 2. Aggregate Travel Time (in hours) Savings by Governorates



Source: Map created using ArcMap**.**

3.1. The Upper Egypt – Red Sea Road

The greatest travel time savings—48.6 hours—were gained by south Sinai governorates. About half of these savings were garnered via the "Upper Egypt – Red Sea Road" (Figure 3.). This 180 km roadway connects Upper Egypt governorates to Red Sea governorates. The roadway was widened to two lanes (7.5 meters wide in total) at a cost of E£848 million. Figure 3.2 shows the distance and travel time of a trip using this new road link (between the capital cities of South Sinai and Sohag governorates). The Google Map estimates suggest that, due to the Upper Egypt–Red Sea Road, the distance between the two end points decreased 37% from 884 km to 543 km and the travel time between them decreased by 2.15 hours.

Figure 3. The Upper Egypt – Red Sea Road

Figure 3.1 The plan of Upper Egypt-Red Sea Road. Source: The Ministry of Transportation (2016)

Figure 3.2 Google map estimates of travel time between South Sinai and Sohag.

Source: The Ministry of Transport (2018).

3.2. The Regional Ring Road

Another important new road is the 400 km Regional Ring Road which connects seven governorates; Ismailia, Suez, Sharkeya, Qaliobya, Monofya, Giza, Fayom with the Cairo governorate (Figure 4.). According to the General Authority of Roads, Bridges and Land Transportation statistics, the government will gain profits not less than LE1 billion from the Regional Road (Egypt Independent, 2018). The road will help in increasing the trade movement between Upper Egypt, Delta and Suez Canal governorates and reducing traffic jams on the main road in Greater Cairo and the Ring Road. The road contributed to about 13 hours savings in travel time gained by the seven governorates.

Figure 4. The Regional Ring Road

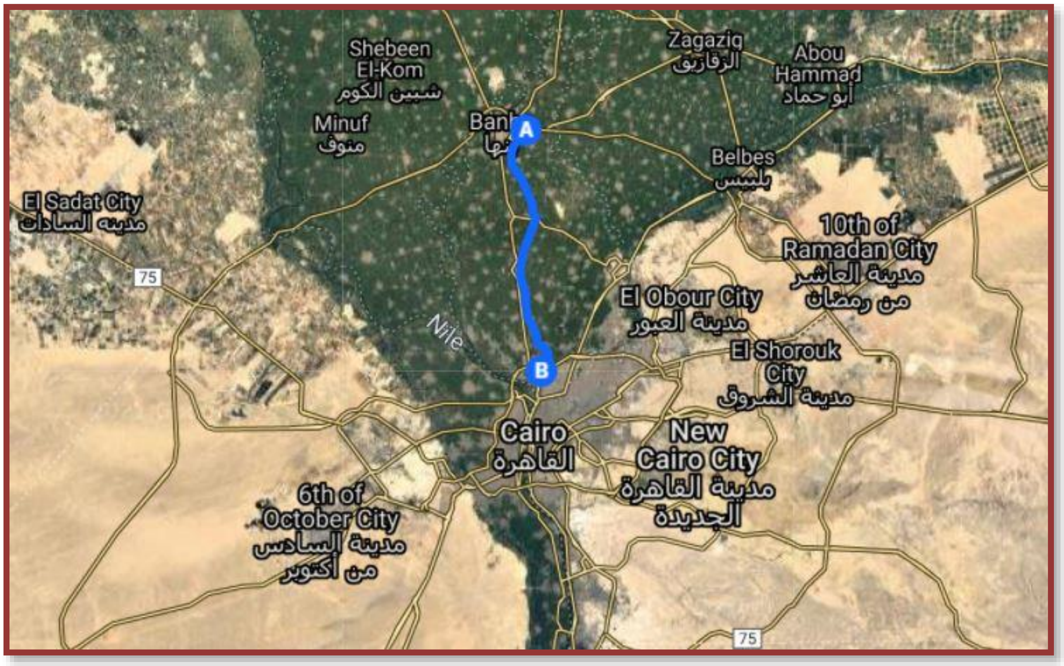
Source: Map created using Google Maps.

3.3. The Shobra – Banha free Road

The length of the road is 40 km, and its width is 41 meters. It includes four lanes, each with a width of 3.65 meters. The road includes 62 industrial works (38 bridges and 24 tunnels)—see Figure 5. The daily traffic volume is expected to reach 60,000 cars per day. The average travel time is 25 minutes, saving 65 minutes per trip.

The road was created with the aim of diverting traffic congestion from the ring road in Greater Cairo and the old “Shubra-Banha” road, it connects six main links: Greater Cairo Ring Road; the Regional Ring Road; the Benha-Mansoura Road; the Minya al-Qamh – Zagazig Road; and the Cairo-Alexandria Agricultural Road. This new road is of a special importance for the people of the governorates of Dakahlia, Sharkia, and Menoufia.

Figure 5. The Shobra – Banha Free Road



Source: Map created using Google Maps.

4. The Economic Impacts of the National Road Project

Savings in travel time due the constructed new roads that have illustrated in Section 3 shows that almost all regions benefit from the new roads. The single-trip aggregate travel time savings by region range from 5 to 48 hours. We then proceed to calculate the change in transportation costs associated with changes in those travel time. The change in transportation cost among regions is considered the primary direct effect of the National Road Project. We use the change in travel time to calculate the change in cost for domestic and international trade flows using the following two estimated functions.

$$\Delta T_i = 0.53875 \cdot \Delta tt_i^{0.65914}, \qquad \text{(domestic trade cost function)}$$

$$\Delta T_i = 3.65506 \cdot \Delta tt_i^{0.71851}, \qquad \text{(international trade cost function)}$$

Where ΔT is the change in transportation cost, Δtt is the change in travel time enabled by the project.

The change in transportation cost to/from all governorates is the economic shock that we enter into our SCGE model. We use the SCGE model to estimate the short- and long-run impacts of the project on both national and regional variables. A distinguishing feature of short- versus long-run simulations is the treatment of the capital stock. Short-run simulations are characterized by an assumption of fixed capital stock. That is, industries' capital stocks are held at their preshock level while, in the long run, policy changes affect capital stocks. We run the two closures (short run and long run) to estimate the impact of the change in transportation cost due to the project on some selected variables.

Our simulations focus on the transportation cost change impact on efficiency gains (real GDP), household consumption and export for the short run. As the reallocation effect become relevant in the long run, we investigate too the change in national investment.

4.1. The Economic Impacts at the National Level

In this section, we discuss the national results of the National Road Project on Egypt's economy. We focus on the efficiency gains (real GDP) and other national variables that could help in verifying the source of the real GDP change due to the transportation cost change shock to our model. We discuss the results of the GDP components: real household consumption, exports and imports in both short and long runs.

Table 1 presents simulation results for national aggregates in both the short and long runs. Gains in efficiency are realized from the project in both the short and long runs. The export volume is the positive component of the GDP in the short run, while in the long run both real household consumption and export volume improve.

Table 1. Short- and Long-run Effects of Some Selected National Variables

National Level	Short Run	Long Run
Real GDP	0.288	0.269
Real household consumption	-0.429	0.355
Export volume	1.685	0.327
Import volume	-1.019	0.291
Utility	-0.743	0.731
GDP deflator	-3.526	-0.573
CPI	-2.837	-0.510

4.2. The Economic Impacts at the Regional Level

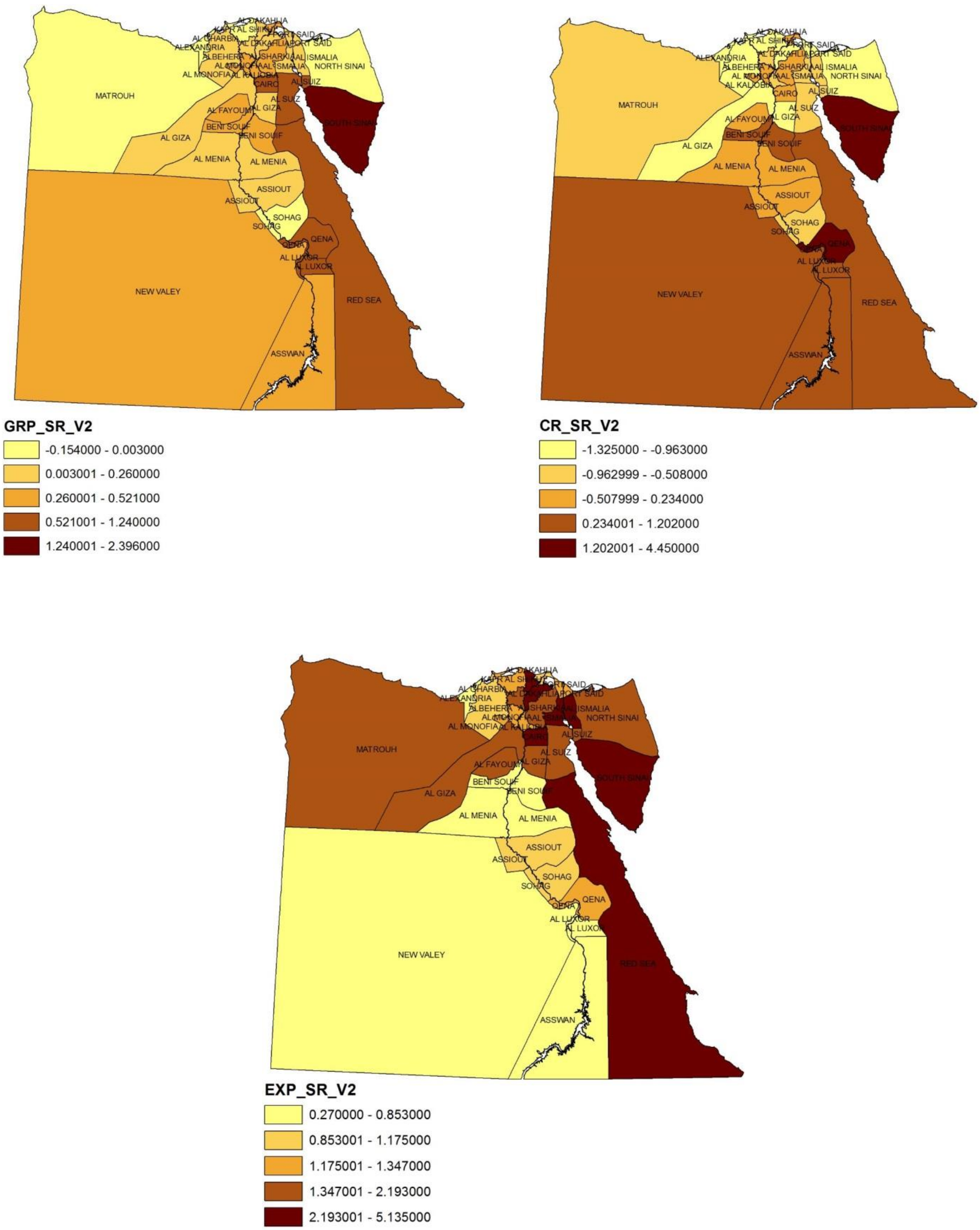
In this section, the analysis focuses on project effects at the governorate level in the short run and upon the allocation of economic activity in the long run. We estimate the project impacts on regional growth (change in GRP), regional household consumption, export in both short and long runs and investment only in the long run. Note that, as mentioned earlier and described by Haddad et al. (2016), we model the locus of production and consumption in each governorate at its capital and assume all international trade occurs only through Alexandria.

The model results on selected regional variables are summarized in Tables 2 and 3. The impact on GRP in the short run is positive in almost all governorates due entirely to the substantial rise in exports since it is apparent that household consumption falls in most governorates. Any positive change in household consumption in the short run is limited to those few governorates that had the greatest gains in travel time savings to other regions. Also, exports rise for all governorates.

Table 2. Short-Run Effects on selected Regional Variables (percentage change)

Regions	Governorates	GRP	Household Consumption	Export
REG_1	**Cairo**	0.614	-0.302	3.275
REG_2	**Alexandria**	-0.008	-1.157	0.781
REG_3	**Port Said**	0.119	-1.325	1.269
REG_4	**Suez**	0.798	-0.508	2.193
REG_5	**Damietta**	0.352	-0.093	0.931
REG_6	**Dakahlia**	0.116	-1.161	3.247
REG_7	**Skarkia**	0.521	0.234	1.538
REG_8	**Kalyoubia**	0.372	-0.657	1.341
REG_9	**Kafr El-**	-0.114	-1.306	1.326
REG_10	**Gharbia**	0.181	-0.757	1.537
REG_11	**Monufia**	0.386	-0.356	1.347
REG_12	**Beheira**	0.057	-0.998	1.133
REG_13	**Ismailia**	0.260	-0.777	5.135
REG_14	**Giza**	0.208	-0.963	1.665
REG_15	**Beni Suef**	0.460	0.487	0.853
REG_16	**Fayoum**	0.287	-0.264	1.567
REG_17	**Menia**	0.079	-0.080	0.270
REG_18	**Asyout**	0.231	0.007	1.175
REG_19	**Suhag**	-0.030	-0.721	1.175
REG_20	**Qena**	1.240	2.535	1.311
REG_21	**Aswan**	0.364	0.689	0.636
REG_22	**Luxor**	0.635	1.147	0.824
REG_23	**Red Sea**	0.631	1.202	3.106
REG_24	**El-Wadi El-**	0.478	1.025	0.702
REG_25	**Matrouh**	0.003	-0.701	1.656
REG_26	**North Sinai**	-0.154	-1.296	1.578
REG_27	**South Sinai**	2.396	4.450	3.760

Figure 6. Spatial regional results in the short run



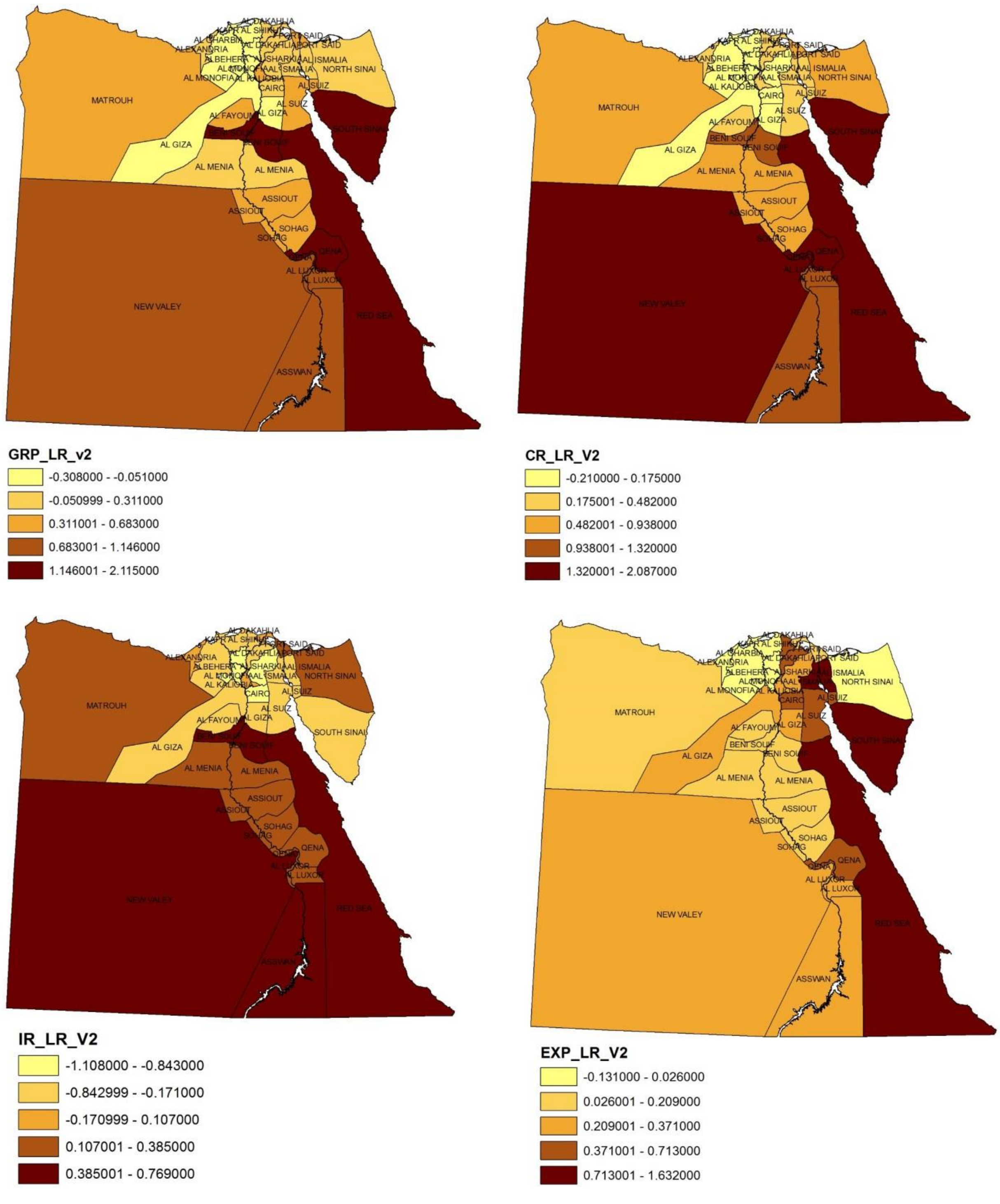
Source: Created using ArcMap.

Figure 6 is a map of the distribution of the short run results across regions. GDP and household consumption impacts across governorates show those governorates that win travel time savings after the construction of the project tend to gain the most efficiency benefits. The impact on export is positive in all regions. However, the regions that gain more export benefits are the regions that locate close to the port (Alexandria) except Red Sea governorate that have the highest change in export volume along with South Sinai.

Table 3. Long-run Effects on Selected Regional Variables (% change)

Regions	Governorate	GRP	Household Consumption	Investment Expenditures	Export
REG_1	Cairo	0.216	0.096	-0.843	0.713
REG 2	Alexandria	0.100	0.383	0.107	-0.005
REG 3	Port Said	0.453	0.701	0.238	0.209
REG 4	Suez	0.590	0.471	-0.260	0.624
REG 5	Damietta	0.310	0.457	-0.064	0.123
REG 6	Dakahlia	0.110	0.287	-0.171	0.566
REG 7	Skarkia	0.238	0.175	-1.044	0.286
REG 8	Kalyoubia	0.375	0.426	-0.020	0.363
REG 9	Kafr El-	-0.169	0.078	-0.421	-0.121
REG 10	Gharbia	-0.308	-0.210	-1.064	0.026
REG 11	Monufia	-0.051	-0.059	-1.108	-0.030
REG 12	Beheira	-0.073	0.111	-0.487	-0.131
REG 13	Ismailia	0.286	0.376	-0.260	1.099
REG 14	Giza	-0.070	0.046	-0.397	0.231
REG 15	Beni Suef	1.391	1.320	0.466	0.059
REG 16	Fayoum	0.469	0.482	-0.191	0.154
REG 17	Menia	0.311	0.643	0.194	0.145
REG 18	Asyout	0.683	0.938	0.309	0.163
REG 19	Suhag	0.425	0.713	0.319	0.104
REG 20	Qena	1.497	1.605	0.298	0.585
REG 21	Aswan	0.872	1.203	0.473	0.369
REG 22	Luxor	0.901	1.186	0.312	0.371
REG 23	Red Sea	1.482	1.620	0.670	1.389
REG 24	El-Wadi El-	1.146	1.734	0.769	0.258
REG 25	Matrouh	0.495	0.754	0.385	0.078
REG 26	North Sinai	0.272	0.801	0.260	-0.028
REG_27	South Sinai	2.115	2.087	-0.321	1.632

Figure 7. Spatial Regional Results in the Long Run.



Source: Created using ArcMap.

In the long run, the result on household consumption turns positive in most governorates and the result on exports is positive for most of the governorates too. Changes in real investment are positive in almost half of the governorates. Figure 7 sections, shows large positive impacts on GDP, real household consumption, investment and export in all governorates that gain high savings in travel time due to the project (see Figure 1: Qena, Aswan, Luxor, Red Sea, and ElwadiElgaded).

5. Conclusions

In this paper, we use a spatial CGE model to assess the interregional economic effects of the updated transportation network of Egypt. We focus on possible changes in national economic growth and regional activities. We use a model developed by Haddad et al. (2016) and extended by Elshahawany, Haddad, and Lahr (2017) to examine the economy before and after 4,500 kilometers of new road were enabled by the National Roads Project. We find that, to date, the National Road project has had a strong, positive effect on Egypt's economy. Both nationally and regionally, the measured impacts are positive, reflecting net gains in efficiency. The governorates that have reaped the most savings in travel time have tended to obtain the greatest economic gains.

Despite the importance of this giant project and its considerable budget, this is the first known set of estimates of the project's economic impacts. We are certain ours are the first governorate-level estimates. SCGE models akin to ours can help in capture the economic impacts of other transportation improvements such as bridges, railways and river transport. That is, they can support government decisions on such projects.

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