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TRANSPORT INFRASTRUCTURE INVESTMENT, COMMUTING, AND WAGES

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Abstract

This study examines the contribution of road and rail investment to the increase in economic activity in Israel. We focus on the contribution to the increase in commuting—daily travel from home to work by people whose workplace is not in the district where they live—because the bottleneck of the transport system occurs in the morning and afternoon rush hours when people travel to and from work. We estimate a model at the level of natural districts (of which Israel has fifty), and this shows that total infrastructure investment in 1993–2003 explains about two-thirds of the total increase of 240,00 commuters in that period, with men accounting for most of the increase. Using data on the different districts we also examined the impact of total road investment in 1992–2004 on men's wage level, and found that the investment increased wages by 10–14 percent.

1. INTRODUCTION

Investment in overland transport infrastructure is immensely important for the development of a modern economy and the narrowing of economic disparities between periphery and center. A strategic plan produced for the Government of Israel by a team of professors of economics indicates how important it is.[1] The team attributed supreme significance to two fields: education and transport infrastructure. "A veritable revolution would take place in Israel," the report stated, "if workers had access to appropriate vocational-training centers and most workplaces . . . The construction of a good and rapid transport infrastructure that links peripheral localities to main urban centers may be very helpful in mitigating alienation and narrowing gaps [between periphery and center]." The team emphasized that in Israel there are marked economic differences between peripheral areas and the center of the country, and that transport infrastructure capital stock is much lower in Israel that it should be and lower than the norm in advanced economies. Increasing that capital stock would transform the peripheral areas and the center into one economic area, as the geographical distances from the center of the country to those areas (apart from localities south of

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[1] "National Socioeconomic Priorities," written for Prime Minister Ehud Barak in 2000. The team was headed by Professor Haim Ben-Shahar.

Beersheba) are no greater than those between residential suburbs and centers of employment in the US.

An efficient road infrastructure makes its contribution by improving firms' access to potential customers (markets), suppliers, and workers. Firms that have access to distant markets can increase their sales and thereby, utilize economies of scale. Rapid and regular access to suppliers allows firms to adopt more efficient and economical production methods in terms of inventory. Access to workers in distant locations allows the economy to use its existing human capital more efficiently. This study focuses on the contribution of transport infrastructure to the improvement of access between firms and workers. In a modern economy that is intensive in knowledge and expertise, the matching of expert workers with firms that need specific knowledge may be immensely valuable (and decreases the importance of cost-cutting in the haulage of intermediates and outputs). An efficient transport infrastructure facilitates the matching of workers and firms that are geographically far apart; hence its importance.

This study estimates the effect of road and rail investments on the extent of commuting in Israel based on the basic gravitation model. The basic gravitation model estimates the extent of commuting between an origin region and a destination region by employing three explanatory variables: population size (or extent of economic activity) in the origin region, population size (or extent of economic activity) in the destination region, and distance between the two regions We deviate from the basic gravitation model and take a difference-in-differences approach. We estimate the growth in (origin-destination) commuting between 1993 and 2003 by using three basic explanatory variables: population growth in the origin region, employment growth in the destination region, and overland transport investments (between 1993 and 2003). Obviously, our main interest is in testing the effect of overland transport investments on the extent of commuting between origin and destination regions. The use of a gravitation model to estimate the contribution of transport infrastructure investment to worker flows is advantageous in two important ways. First, it allows us to estimate directly the main way in which road investment affects product, i.e., by increasing labor mobility. The bottleneck in any road system, of course, is the morning and afternoon rush hour, when most commuters are making their way to and from work. According to surveys by Israel's Central Bureau of Statistics, half of all trips are taken during six hours only: 6:00–9:00 and 15:00–18:00. A supplemental investment in road and rail transport would have its main effect on the increase in product, by increasing the use of transport infrastructure at peak hours (for commuting purposes), whereas at other hours the roads are not an effective obstacle to an increase in economic activity.[2] The second advantage of the gravitation model is that it utilizes differences in road investment and mobility patterns between different parts of the country. Consequently, we do not need to use lengthy time series of macroeconomic factors that affect mobility patterns, such as prices of motor vehicle upkeep and fuel, and business cycles, to name only two.

[2] Road investment does help to cut the cost of transporting goods and raw materials, but most of this activity may also be undertaken outside peak hours. Reducing costs of freight haulage is of limited significance because most of Israel's product originates in services and high-tech manufacturing; only a small fraction stems from heavy and other industries that entail significant haulage costs.

Over the years, capital stock and commuter flows are mutually self-adjusting. However, the positive correlation that the standard model shows between capital stock and commuter flow does not necessarily indicate the direction of causality: did capital stock adjust itself to the commuting patterns, or did the commuting patterns adjust themselves to capital stock?[3] To isolate the effect of capital stock on commuting, we estimate the gravitation model relative to a point of time in the past, i.e., we explain the commuter flow in the present (2003) by means of the commuter flow in the past (1993) and avail ourselves, as an auxiliary factor, of the *change* in capital stock (the change in road and rail investment between 1993 and 2003). We chose the decade-lagged commuter flow as a compromise between two constraints. On the one hand, transport projects in Israel take a long time to mature (roughly five years of investment until the completion of the project), making it necessary to choose a relatively long lag so that the data will illustrate the completion of projects and the adjustment of commuter flows to them. On the other hand, an excessively lengthy lag should not be chosen because it would be irrelevant in explaining current commuter flows and would not help to solve the problem of variable omission. The omission of relevant variables in explaining commuter flows (e.g., GDP of destination region) may bias the results of the regression; the inclusion of commuting at a lag is a surrogate for the omitted variables because the same variables affected commuting patterns in the past.[4,5]

The gravitation model estimates the extent of commuter flows but not their added value. A similar problem occurs when a gravitation model is used to estimate flows of international trade: the model explains the extent of trade flows but does not explain how much the increase in international trade contributed to the GDP. Conventional wisdom has it that an increase in trade boosts product, but estimating the extent of the effect has been the subject of many studies. Also, there are exceptional cases in which restraints to foreign trade, such as an arms embargo, will induce the affected country to establish a new industry that has high learning potential, placing its economy on a higher growth trajectory. By way of parallel, inadequate investment in roads between cities that have a bidirectional commuter flow may prompt workers in both cities to relocate to places near their work; such a development might result in more labor hours (at the expense of travel time), product, and welfare. To confirm our hypothesis that enhancing access contributes to product, we test the proposition that road investment increases labor wage.[6]

[3] For example, the high level of road capital stock in metropolitan areas is largely the outcome, and not the cause, of the commuter flow.

[4] However, a bias is still possible due to the omission of variables that explain the *change* in the commuting patterns. The model may identify a causal relationship between road/rail investment and commuting if the investment is determined in accordance with present transport loads and future expectations of load that come to pass (e.g., expectations about population size in 2003). If the road investment is determined by means of expectations of developments in traffic load, and if these expectations are based on variables that are not included in the model, then the problem of coefficient bias (and the endogeneity problem) will not be totally solved.

[5] Another problem that occurs if too early a period of time is chosen stems from migration between regions, which may change the composition of the population in the various regions. However, we remove the sting from this problem by controlling for personal traits.

[6] The relationship between an increase in the commuting rate and economic growth cannot be examined because both variables may be affected by an exogenous (extra-regional) shock. For example, a decline in

The impact of infrastructure investment on economic growth was first examined by Aschauer (1989), who used an augmented aggregate production function including total public infrastructure as an additional input. Looney and Frederiksen (1981) specified the effect of transport infrastructure capital on regional growth. Prud'Homme (1996) and Fritsh and Prud'Homme (1997) estimated the effect of road investment on productivity in France using a cross section of the 21 regions. We follow Evers et al. (1987) who used a gravitation model to estimate the effect of the Amsterdam–Hamburg railway line on regional economic activity. In their opinion, the line makes its main contribution by improving firms' access to distant customers. This allows firms to exploit economies of scale and thereby enhances productivity and product. In the empirical section Evers et al. used a gravitation model to estimate interregional trade in accordance with the levels of activity in the origin and destination regions, and travel costs between the former and the latter in terms of time. They distinguished between tradable and non-tradable industries because economic activity can be diverted in tradable industries only (and not in agriculture)[7]; therefore, one would expect an increase in productivity to occur in tradable industries. One may draw a parallel between Evers et al. and our study. In our study, the advantage of transport infrastructure in improving firms' access to workers replaces the enhancement of firms' access to customers, and the advantage of more suitable matching of workers and firms replaces scale economies. Their method of estimation is quite similar to ours. However, while Evers et al. estimate the effect of transport infrastructure on total employment in a region, we estimate its effect on commuter flow. Since commuter flow corresponds more closely to transport infrastructure, this offers an advantage (originating in the quality of the data in our possession). Furthermore, whereas Evers et al. estimate the direct effect of reducing travel time, we estimate a more indirect effect, mediated by investment value. This is due to a data constraint (in that travel times are known in rail transport but not in road transport).

This study examine how wages in a given region are affected by road investment. Studies in various countries have estimated the contribution of road investment in a given region to increases in employment, product, and wages in the region. This study focuses on examining wages only, due to the lack of data about regional product (and because the employment rates of potential commuters in Israel are high and very stable). Road investment in the region will affect wages in the region itself and in other regions that have a commuting relationship with it. We examine the effect of wages in the region itself and in its main destination region only; the study cannot be expanded to additional destination regions due to the data constraint. Notably, the effect on wages in the region itself may not be positive because the road investment will also increase inbound commuting, causing a downward effect on wages in the region.

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security in Jerusalem would dampen economic activity there and reduce commuting to Jerusalem, but in such a case there would be no causal relationship between the decrease in commuting and the decrease in economic activity.

[7] Rietveld (1989) discusses and expands on Evers et al.

Even though the use of a gravitation model involves difficulties, we preferred it to the estimation of a production function, which has been a more conventional way of estimating the contribution of infrastructure investment to product since Aschauer (1989).[8] A production function estimates the business product of an economy via the proxies of capital and labor quantity, capital and labor quality, and additional variables including infrastructure capital. Such an estimation is problematic in the case of Israel due to the severe volatility of Israel's business product and the strong stability of its road capital stock. Furthermore, we would be concerned about finding a spurious correlation between road investment and business product for several reasons: (1) economic growth leads to a larger budget surplus and allows the government to increase road investment; (2) the increase in road investment may be part of a comprehensive pro-growth policy that includes components that are omitted from the production function; (3) both product and road capital stock increase over time (i.e., they are non-stationary variables). Another problem that makes the estimation difficult is that it takes many years to complete transport projects and only when they are finished can one expect the increase in product to occur. (The problem originates in the irregularity of timing of the maturing of transport investments.)

There are many who consider commuting, and also road investment, as harmful. Certainly, commuting entails not insignificant costs: the time lost while traveling, direct expenditure on fuel/petrol/gas and depreciation, the risk of being injured in an accident, physical and mental health implications of being stuck in long traffic jams, etc. Nevertheless, despite its drawbacks, it seems that commuting improves commuters' situation; if not, they would not choose to commute (the revealed preference theory), as they bear the brunt of its negative effects.[9] Some of the costs of commuting, however— mainly air pollution, noise, and increased traffic congestion— are borne by the general public, but commuters compensate for this by paying taxes on fuel and vehicles, and as a group, they themselves suffer most from the congestion which they cause. Another negative feature associated with road investment is its effect on the urban structure: from a crowded town with one main center in which most economic activity takes place, to the development of distant residential areas close to which many separate activity centers develop. The switch from the first to the second, from the centralized to the dispersed, in the final analysis has an adverse impact on the public: public transport becomes less efficient, there is greater dependence on private transport, and congestion costs increase. The objective of reducing congestion costs by additional road investment results in another increase in demand for suburban housing, which incurs over-use of land and leads to further weakening of the town center and increased congestion, a vicious circle. The long-term effects of road investment on urban structure are complex and fall outside the scope of the

[8] Many studies use a production function to estimate the contribution of public capital stock to overall product. Mera (1973) used a production function to estimate the contribution of transport capital stock only. Fritsch and Prud'Homme (1997) estimated the contribution of road investment in France by means of a regional production function informed by cross-sectional data for twenty-one regions and regional road capital stock. Gkritza et al. (2007) estimated the effects of road investments on a regional economy by examining the effect of freeway construction in Nevada (U.S.) on employment, output, and disposable income.

[9] Frey and Stutzer (2004) found that commuters' feeling of wellbeing is lower, ceteris paribus; this constitutes a paradox for supporters of the rational choice theory.

current study, partly because suburbanization (the move of population from towns to the rural-urban fringe, or urban sprawl) essentially results from a town planning decision and not from road building decisions. Road building will probably boost the demand for suburban housing, but without building permits from the planning authority there will not be additional residential construction.

Our study found that road and rail investments in 1993–2003 increased commuter flow in Israel by about 160,000 persons (including 14,000 due to rail investments) and explain two-thirds of the total numerical increase in the commuter population. It also found that the main contribution of government investments in roads is reflected in more commuting between contiguous natural regions; the contribution to increased commuting between more widely separated regions is relatively small. The effect of rail investment, in contrast, is evident mainly in connecting distant and non-contiguous regions. Another important outcome is that the total road investment in 1993–2003 boosted men’s wages by 10–14 percent. The increase traced to road investment in the region itself and in its main destination region; it does not include the contribution of secondary destination regions.

The study is structured as follows: Section 2 presents the estimating strategy Section 3 presents the data and the descriptive statistics, Section 4 examines the effect of road and rail investments on commuting, Section 5 explores the effect of the road investments on wages, and Section 6 concludes.

2. REVIEW OF THE LITERATURE

Three studies have been carried out in Israel to estimate the effect of infrastructure capital stock, using a production function. Bergman and Marom (1993) estimated the effect of infrastructure capital stock—roads, communications, electricity, sewage, rail, and seaports and airports—on Israel's business sector product. The study was based on panel data for seven selected years between 1958 and 1988, which were used to estimate the Cobb--Douglas production function, which included physical capital, labor, human capital, indices of the openness to international trade, and the stock of infrastructure capital. They found very high rates on return on investment in the physical infrastructure, 54–70 percent, and on investment in human capital, 14–33 percent. In a separate study, Bergman and Marom (1998) estimated a production function for manufacturing output only, using panel data for 1960–1996 on seventeen main manufacturing industries. In that study the change in manufacturing output is explained by business capital, labor, infrastructure capital, R&D capital, labor force features, and the effect of the openness of the economy and inflation. In this study the rate of return on infrastructure capital was found to be lower, 15 percent. The average rate of growth in the period was 6.2 percent, and the contribution of infrastructure capital to the annual growth rate was estimated at only 0.1 percentage points. The main contribution to growth was made by labor (1.9 percentage points) capital (1.7 percentage points), R&D capital (1.4 percentage points), and the openness to international trade (0.1 percentage points). The other variables, including human capital, were found to have no significant effect on manufacturing output. The two studies relate to different periods and to different products/outputs, but the wide gap between the contributions of human capital and infrastructure capital indicate the great difficulty in estimating policy variables by means of a production function. The difficulty would only grow if we were to try to isolate the effect of the transport infrastructure from total infrastructures. (Roads constitute only about 20 percent of total infrastructure.) In a third study, Shahrabani (2007) examined the effect of infrastructure capital on productivity on the principal industries in Israel in the years 1990–2003. In addition to roads and other overland transport, infrastructure capital included seaports and airports, communications, electricity, and waterworks. The study estimated the cost of product separately for each of twenty-three industries as a function of wage costs, capital costs, the extent of activity, and infrastructure services (infrastructure capital stock multiplied by the extent of its use). The rate of return on infrastructure capital was found to be 11–13.5 percent. It was also found that infrastructure capital is a substitute for private capital, and it does not lower the cost of labor.

Although the study by Presman and Arnon (2006) did not deal specifically with road investment, it is relevant nonetheless, as it uses a gravitational model to explain commuting patterns in Israel in 1991–2004. The dependent (or explained) variable is the number of commuters from the district of departure (origin or source district) to the destination district. The variables found that act to increase commuting (the independent, or explanatory, variables) were the size of the labor force in the source district, the size of the labor force in the destination district, the geographical proximity of the two areas, the difference in wages between them (the average wage differential, by industry), and the difference between the employment rates (share of employed persons in the labor force) in the two areas. Other independent variables examined were found not to be significant: the share of young workers or of those with higher education in the two areas, the number of children aged up to four years, the rate of unemployment, and housing congestion; the composition of the average population was also found not to affect the average extent of commuting in the area. These variables, however, did have a considerable effect on the individual: commuting was more common among those with higher education, among men, and among the young and less-than-middle-aged (and less so among those with low levels of education, women, and those aged 55+).[10]

Many studies carried out around the world have used a production function to estimate the contribution of public capital stock to GDP. Mera (1973) used it to estimate the contribution of the stock of transport capital alone. Fritsch and Prud'Homme (1997) estimated the contribution of road investment in France by means of a regional production function, using cross-sectional data of twenty-one regions and regional road capital stock. Gkritza et al. (2007) estimated the contribution of road investment on the economy of the region. They examined the effect of the construction of highways in Nevada, USA on employment, output, and disposable income.

Evers et al. (1987) used a gravitation model to estimate the effect of the Amsterdam–Hamburg railway line on regional economic activity. In their opinion, the line makes its main contribution by improving firms' access to distant customers. This allows firms to exploit economies of scale and thereby enhances productivity and product. In the empirical

[10] The reason is the relatively small difference between the average composition of the population in the two areas.

section Evers et al. used a gravitation model to estimate interregional trade in accordance with the levels of activity in the origin and destination regions, and travel costs between the former and the latter in terms of time. They distinguished between tradable and non-tradable industries because economic activity can be diverted in tradable industries only (and not in agriculture)[11]; therefore, one would expect an increase in productivity to occur in tradable industries. One may draw a parallel between Evers et al. and our study. In our study, the advantage of transport infrastructure in improving firms' access to workers replaces the enhancement of firms' access to customers, and the advantage of more suitable matching of workers and firms replaces scale economies. Their method of estimation is quite similar to ours. However, while Evers et al. estimate the effect of transport infrastructure on total employment in a region, we estimate its effect on commuter flow. Since commuter flow corresponds more closely to transport infrastructure, this offers an advantage (originating in the quality of the data in our possession). Furthermore, whereas Evers et al. estimate the direct effect of reducing travel time, we estimate a more indirect effect, mediated by investment value. This is due to a data constraint (in that travel times are known in rail transport but not in road transport).

3. DATA AND DESCRIPTIVE STATISTICS

The sources of our data on road investments are the Israeli Government budget books for 1992–2004, which provide an itemized list of all interurban projects. Overall, 150 projects were carried out during these years (not including projects in Judea-Samaria). Each project is itemized by location (including origin and destination), type (widening of road, building of new road, building of interchange, etc.), year project started, and annual investment and cumulative investment performed. We used these data to calculate road investment in each natural region. Road investment in each natural region was calculated in accordance with financial value as opposed to road length, because a larger investment usually attests to a higher quality road that has many interchanges. Another important metric is road capital stock in each natural region. The amassing of road capital stock in Israel and its apportionment among natural regions were measured by the Central Bureau of Statistics (CBS).

Our main source of data on commuter flow was the CBS labor force surveys for 1992–94 and 2002-04. The surveys provides detailed information about individuals' schooling, age and sex, as well as information about their places of residence and their places of work. On the basis of this information, we defined a commuter as a person who works outside his natural region of residence. (The unemployed were omitted from the study.) A natural region is a smaller geographical region than a sub district (and a district). Israel has fifty natural regions; they are larger in sparsely populated places and smaller in densely populated ones. (See map in the Appendix.)

Our examination of nationwide commuting patterns shows that one-third of employed Israelis work outside their natural region of residence and that the share of commuters

[11] Rietveld (1989) discusses and expands on Evers et al.

among employed persons rose by 2.8 percentage points during the decade.[12] As a rule, travel distances between home and work are not large in Israel: the large majority of employed persons (86 percent in 2003) are employed in their natural region of residence or in an adjacent one. Only 12 percent of employed persons commute more than 20 kilometers (bee line distance) and only one-fifth commute more than 50 kilometers. Examination of commuter flows in the Tel Aviv natural region, the main destination of commuters in Israel, reveals a very appreciable decline in commuting to this destination: from 38 percent of all commuters in 1993 to 31 percent a decade later. Most of the upturn occurred in natural regions that belong to the Central District—which is the near periphery of Tel Aviv.

Table 1
Commuting Rates (Working outside Natural Region), 1993 and 2003, percent

	1992–1994	2002–2004
Share of commuters among employed persons countrywide	30.4	33.2
Average commuter travel distance (km.)	19.3	21.9
Share of commuters to non-contiguous national region (among employed persons countrywide)	10.8	14.0
Share of commuters who travel 20+ km. (among employed persons countrywide)	9.0	12.1
Share of commuters to Tel Aviv natural region (among total commuters)	38.2	30.9
Share of commuters among employed persons living in Northern and Southern districts (periphery)	24.5	28.0
Average distance traveled by commuters who live in periphery (km.)	30.9	33.0
Share of men who commute	35.6	38.8
Share of women who commute	23.5	27.2
Average travel distance of men commuters (km.)	21.3	24.4
Average travel distance of women commuters (km)	15.1	18.0
Share of persons aged 20-40 who commute	32.3	35.7
Share of persons aged 41-65 who commute	29.6	31.4
Share of persons with 13+ years of schooling who commute	32.2	35.9
Share of persons with up to 12 years of schooling who commute	29.5	30.3

As for commuters who live in the Northern and Southern districts (hereinafter: the periphery), a large proportion work 20 kilometers or more from their homes (surpassing the national average). Although the share of workers from outside the natural region among inhabitants of the periphery is below the national average, this is because the peripheral natural regions (especially in the south) are relatively large.

As expected, commuting is more prevalent among men, the young (the highest rate was found in the 20–40-year age cohort; it declines gradually as age rises), and the well schooled. The increase in commuting during the decade was stronger among groups that had high rates of commuting to begin with—the young and those with higher education—than among their complements. In contrast, the commuting rate of women, which was low at the outset, increased considerably.

[12] Between 1993 and 2003 the number of commuters increased by 41 percent while the number of persons employed advanced by 29 percent.

The change in commuting patterns varies widely between natural regions: in thirteen natural regions, the number of commuters out of the region increased by more than 90 percent between 1993 and 2003, and in seven natural regions their numbers increased by less than 10 percent. (In twenty-seven other regions, their numbers grew by 10–90 percent.) There was also much variance in road investment: eight natural regions had no investment during the research period and ten natural regions enjoyed more than $ 66 million in investment (at 1995 prices). This variance helped us to examine the extent to which the inter-regional difference in road investment explains differences among regions in the development of commuting patterns. The use of inter-regional variance allows us to neutralize the effect of road investment on commuting country wide, without having to account for changes in fuel and motor vehicle prices, business cycles, etc.

4. THE GRAVITATION MODEL—THE EFFECT OF ROAD INVESTMENT ON INTER-REGIONAL COMMUTER FLOW

The gravitation model relates to commuter flow between origin and destination regions. The common gravitation model can be described and estimated as follows:

(1) $$C_{i,j} = c + a_1 Pop_i + a_2 Work_j + a_3 D_{ij} + a_4 Border_{ij} + a_{m+1} Roadinv_i + a_{m+2} Roadinv_j + X_i + X_j + u_{i,j}$$

The number of commuters between origin region *i* and destination region *j*, $C_{i,j}$, depends on the size of the population in the origin region (Pop_i), the number of persons employed in the destination region ($Work_j$), the distance between the regions (D_{ij}), the contiguity of the regions ($Border_{ij}$), road investment in the two regions ($Roadinv_i$ and $Roadinv_j$) and anther explanatory variable (X_i and X_j). Regression 1 (Table 2) estimates such a model.

The explained variable in Regression 1 (and in all the other regressions in Table 2) is the average number of commuters between origin and destination in 2002–04 (hereinafter: 2003). The explanatory variables in the model behave in the expected way (with the exception of the rail variable). Thus, population size in the region of origin (in 1993) and the number of employed in the destination region (in 1993) had a significant positive effect on the number of commuters between origin and destination (population size in destination region had no effect). The closer the regions (km. at a bee line) and insofar as they were contiguous, the more the commuter flow between origin region and destination region increased. As for the transport variables, the commuter flow increased in response to an upturn in road investment in the origin region (total real road investment in the region in 1992–2004) and in the destination region. In contrast, connecting two regions to the national railroad system did not affect commuting.

The results of the estimation of Regression 1 may be misleading, because over a period of years capital stock adjusts itself to commuting patterns and vice versa. Large road investments are performed in regions where strong commuting relations have already been established. For example, the largest road investment was made in the Tel Aviv natural region (which is also Israel's main commuting destination region). To solve this problem, we included an additional explanatory variable in all subsequent models: the number of commuters between origin and destination in the past (in 1993). This allowed us to determine whether the *increase* in transport capital stock *increased* the commuter flow. The inclusion of the past extent of commuting probably greatly amplified the explanatory power of the explained variable, the current extent of commuting.

Regression 2 includes the following explanatory variables: annual average number of commuters between origin and destination regions in 1992–1994 (hereinafter: 1993), population increase in origin and destination regions, and distance by air between origin and destination regions.[13] The investment variables are total real road investment in 1992–2004 in the origin region, total real road investment in 1992–2004 in the destination region, and total real road investment in 1992–2004 in "crossed regions," i.e., those between origin and destination. A dummy variable for rail infrastructure development was also included; it was assigned a value of 1 if one (or both) of the regions was connected to the national railroad system during the decade. Finally, we included road capital stock in the natural region, calculated for us by the CBS, as an explanatory variable.

The results of Regression 2 show that the coefficient of past number of commuters is strongly significant and close to 1; it follows that commuting patterns tend to be self-sustaining. The increase in number of commuters is greater when demographic growth in the origin region is greater and when the geographic distance between origin and destination is smaller. As for investment, road investment in origin region and destination region increases the commuter flow significantly, as does the existence of a rail connection in 1993. Road capital stock in the origin and destination regions had no effect (neither did the size of the two regions). The effect of capital stock may be reflected in the other variables, such as past commuting patterns and population size in the origin and destination regions. Another insignificant variable was road investment in crossed regions. This outcome should be treated with caution because not every region defined as crossed is necessarily so, due to limitations in defining the variable.[14] In fact, we were unable to identify the exact regions that commuters cross on their way from origin to destination (due to the range of options available to them); therefore, we were unable to fully estimate the contribution of road investment to commuting between non-contiguous regions.

Regression 3 includes another explanatory variable that Regression 2 omits: the number of persons employed in the destination region in 1993, which was found to be strongly significant. By the same token, the regression omitted two variables that were not significant and that did not affect other variables: road capital stock in the origin and destination regions. The inclusion of persons employed in the destination region lowered

[13] The dummy variable for contiguity of origin and destination regions was not found significant and was therefore omitted; its effect is implicit in past commuting patterns.

[14] The variable of "road investment in crossed natural regions" was devised as follows: first we defined a single reference point in each natural region. (By calculating the average of the latitude and longitude coordinates for all persons in a natural region, we obtained a single point that represents the natural region). Thus, for each pair of origin and destination regions we had a pair of points connected by an imaginary line that constitutes the diagonal of an imaginary rectangle. Each natural region within this imaginary rectangle was defined as a "crossed natural region," i.e., a region situated between origin and destination region. Obviously, not every region defined as a crossed one is truly relevant for the flow of traffic between origin and destination; this evidently explains why this variable is not significant.

the estimator of road investment in the destination region but had hardly any effect on the estimators of road investment in the origin region and rail transport.

Table 2
Effect of Road and Rail Investment on Commuting between Origin and Destination Region Explained Variable: Average Commuters (N) in 2002–2004

	1	2	3	4	5	6	7
	All Regions	All Regions	All Regions	All Regions	Positive Commuter Flow	Contiguous Regions	Periphery Regions
Road investment in origin region	1.163 (0.326)	0.387 (0.089)	0.444 (0.087)	0.350 (0.093)	0.571 (0.111)	1.835 (0.376)	0.128 (0.050)
Road investment in destination region	1.160 (0.351)	0.592 (0.086)	0.259 (0.102)	0.211 (0.103)	0.323 (0.134)	1.167 (0.490)	0.013 (0.056)
Road investment in crossed regions	—	0.006 (0.105)	—		—	—	—
Dummy: connection to rail system	14.2 (180.1)	151.1 (57.0)	141.7 (56.1)	117.2 (56.3)	127.7 (73.9)	–154.3 (206.7)	19.7 (32.4)
Origin–destination commuters in 1993	—	0.971 (0.008)	0.959 (0.008)	0.957 (0.008)	0.949 (0.009)	0.842 (0.021)	1.112 (0.019)
Origin–destination distance (km.)	–54.5 (6.04)	–15.5 (1.40)	–16.9 (1.40)	–17.6 (1.40)	–21.7 (1.99)	–71.1 (29.3)	–5.9 (0.81)
$Distance^2$	0.25 (0.03)	0.069 (0.008)	0.077 (0.008)	0.079 (0.008)	0.100 (0.011)	1.117 (0.669)	0.025 (0.004)
Population increase in origin region	—	3.763 (0.718)	4.234 (0.688)	4.000 (0.722)	5.256 (0.919)	6.06 (2.966)	1.875 (0.385)
Population increase in destination region	—	0.923 (0.703)	1.546 (0.664)	1.536 (0.701)	1.760 (0.876)	4.269 (3.133)	1.269 (0.365)
Employment in destination region in 1993	0.0142 (0.002)	—	0.0019 (0.000)	0.0019 (0.0003)	0.0023 (0.000)	0.0063 (0.002)	0.0008 (0.0002)
Road capital stock in origin region	—	52.2 (30.9)	—	—	—	—	—
Road capital stock in destination region	—	42.2 (30.5)	—	—	—	—	—
Population of destination region in 1993	–1.147 (0.92)	—	—	—	—	—	—
Dummy: contiguous regions	883.6 (221.0)	—	—	—	—	—	—
Population of origin region in 1993	3.23 (0.54)	—	—	—	—	—	—
Additional explenery Variable				+			
Constant	894.0 (248.5)	290.1 (58.2)	365.2 (51.2)	1122.9 (705.6)	400.4 (68.1)	516.4 (299.1)	158.3 (28.3)
Observations	1,117	1,117	1,117	1,117	797	186	1,030
R squared	0.320	0.949	0.951	0.951	0.952	0.971	0.839

Regression 3 allows us to test the quantitative effect of road and rail investment on commuting: The total government investment in roads during the decade ($ 2.5 billion at 1995 prices) increased the number of commuters by 140,000 persons.[15] Concurrently, 127 new origin–destination connections were created by means of railway lines; these boosted the number of commuters by another 18,000. Thus, the total improvement in transport infrastructure explains 65 percent of the total increase in commuting during that period.

Regression 3 includes, in addition to the explanatory variables, several control variables that may affect the change in commuting patterns, e.g., average years of schooling of workers in origin region, average years of schooling of workers in destination region, average age in origin and destination regions, and the proportion of Jews in the origin region. Although these variables were not found to be significant, they had a downward effect on the estimators of infrastructure investments (the total effect of infrastructure investments estimated in this regression was 111,000 commuters).

Regressions 5 and 6 allow us to analyze the sensitivity of the relationship between road investment and commuting according to distance (relative to Regression 3). Regression 5 relates only to origin–destination pairs that had a positive commuter flow in 1993; Regression 6 relates solely to origin–destination pairs that are contiguous. The coefficient of road investment for commuting in contiguous regions was very large, indicating that road investments boost commuting between contiguous regions but not between regions that are far apart.[16] (Bear in mind that most commuter flow—60 percent—is between contiguous natural regions.) In contrast to road investments, which have an effect that is perceptible mainly in short distances, rail service augments commuting between non-contiguous regions. As one can see the effect of rail diminishes in Regression 5 and disappears totally in contiguous regions (Regression 5). Regression 7 performs another sensitivity test, probing the effect of infrastructure investments on commuting between periphery and center and within the periphery. Here, the sample excluded origin–destination pairs that were part of the Tel Aviv or the Central district. It was found that the effect of road investment in origin region on the number of commuters declined severely but remained significant, whereas the effect of investment in destination regions and in rail transport was not significant.

Other sensitivity tests are shown in Appendix 3. They were performed according to Regression 3 in Table 2, which is presented also in Regression 1 in the Appendix Table 3. In Regression 2 in the Appendix Table 3 the control variables for the population increase in the origin and destination districts are replaced by the size of their populations in 1993. The estimate of the contribution of the infrastructures to the increase in commuting rose to 184,000 commuters (compared with 157,000 in Regression 3 in Table 2). Omitting population size in 2003 answers concern that the rates of population growth in both areas

[15] An investment of NIS 1 million in a given natural region increases the outbound commuter flow from the region by six persons and the inbound commuter flow by ten persons (an increase of 0.44 inbound commuters from each of the twenty-three other natural regions). The total investment was NIS 7.5 billion (at 1995 prices)

[16] By running another regression that includes only non-contiguous regions (not presented here), we found that road investments have no significant effect on commuting between non-contiguous regions and that only a rail connection has a significant positive upward effect on this activity.

are affected by infrastructure investment in them (the endogeneity problem), but we are of the opinion that this is a secondary problem, and it is more important to neutralize the effect of demographic growth on commuting. Regression 3 in Appendix Table 3 includes, in addition the explanatory variables in the original regression (Regression 3 in Table 2), several control variables that are likely to affect the change in commuting patterns, such as the average number of years of education of workers in both areas (origin and destination), the average age in both areas, and the proportion of Jews in the area of origin. These variables did not turn out to be significant, but they act to reduce the estimate of infrastructure investment (without affecting the significance level): the total effect of infrastructure investment estimated in this regression was 111,000 commuters.

Additional sensitivity analysis (available from the authors) examines commuting by gender. Road investments in the destination region and rail investments were found to have a significant effect on men's commuting only; road investments in the origin region increased commuting by women and men. The fact that the coefficient of the lagged variable was much higher among women than among men and that the effect on them of investments in the origin region and in rail transit was not significant suggests that the strong increase in the share of women who commute is part of the broader phenomenon of narrowing gender gaps (in schooling, wages, and the labor market) and does not trace to an improvement in transport infrastructure.

We can see from the estimation of different specifications of the gravitational model that investment in Highway 6 (the Cross-Israel Highway) and in the railway in the area of origin and destination area since the year 2000 increased commuting by about 157,000 commuters, which constitutes the greatest part of the total increase of 240,000 commuters in that period. Road investment in crossed regions certainly made a positive contribution to the increase in commuting, although it was not seen as significant because of lack of data. Most of the contribution of road investment was to increase commuting between adjacent natural districts. In contrast, the effect of investment in the railway was felt mainly in connecting non-adjacent districts. Another finding was that the effect of investment in the transport infrastructure in increasing incoming commuting resulted mainly from investments in the main metropolitan areas, Tel Aviv, Jerusalem and Haifa, and its contribution to the increase of commuting by women was relatively minor. Finally, we note that some of the change in the number of commuters was the result of non-regional macroeconomic factors, such as the cost of daily travel (tax relief on cars and fuel). These factors affect all areas, so that they are reflected in the constant (intercept) and in the coefficient of commuting with a lag, and cannot distort the effect of transport infrastructure on commuting.

5. THE EFFECT OF INFRASTRUCTURE INVESTMENT ON WAGES

The main result of the gravitation model relates to the positive effect of road and rail investments on the level of commuting. The next question to ask is whether an increase in road investment in the origin region that induced an increase in commuter flows affected economic activity in the region. To answer this, we focus on the average wage in the region because we have no data on regional product. We also examine the effect of road investment on employment rates, although in general these are very stable (particularly in the age and educational-level groups with high commuting rates).

We found no point in testing the relationship between a regional increase in commuting and the economic development of the region (or the regional wage) because we suspected that both variables were affected by an exogenous shock. For example, if terrorist attacks increase in a tourism-intensive region, fewer tourists will visit the region and, in turn, the regional wage will decline, workers will be fired, and the inbound commuter flow will diminish.

The effect of infrastructure investment on a region's average wage is not straightforward. Road investment in a region increases both outbound flow and inbound flow; while an outflow of workers from a region has an upward effect on the wages of its inhabitants, an inflow of workers to the region has a downward effect on wages. Thus, regional road investment may have a negative effect on the wages of the region's inhabitants, and in any case the wage effect does not reflect the total return to the economy on the road investment because this return also includes an increase in the wages of workers who live in other regions. Unlike infrastructure investment in the region itself (hereinafter: researched region), investment in a main destination region of the researched region is expected to increase wages in the researched region by facilitating outbound flow from it without facilitating inbound flow.

To examine the average regional wage, we used income surveys for 1992–93 and 2002–04, which provide information about personal wages and other important characteristics (schooling, age, days worked, etc.). We limited the inquiry to men, because road investments were found to have a meaningful effect on men's commuting patterns (but no such effect on women's). The sample excluded individuals who worked for less than a full month and Arab residents of East Jerusalem. The main results appear in Table 3; detailed results appear in the Appendix. The explained variable in Regression 1 is daily wage in 2002–04 (monthly wage divided by number of days worked). The wage is explained by personal traits, region of residence traits,[17] and road investment in region of residence in 1992–2004. To control for personal traits, we included the following variables: years of schooling, age, number of days worked, and ethnic group (three separate dummy variables: for Jews of Asian-African origin, for Arabs, and for immigrants). In Regression 1 we also controlled for regional population, regional geographical area, and regional road capital stock. The results of Regression 1 show that road investment had a significant positive effect on wage level.[18] Thus, the quantitative effect of mean road investment per natural region (about NIS 66 million at 1995 prices) raised the mean daily wage of regional inhabitants by NIS 3.3 (at 2003 prices), i.e., by 2.25 percent. However, this is an underestimate because road investment in the researched region also raised the wages of workers in regions for which the researched region is a destination.

[17] To control for region of residence traits, we ran personal wages in 1992–94 against personal traits. The unexplained residues of this regression were sorted by personal region of residence and the mean regional residue was included as an explanatory variable in Regression 1 (in order to neutralize the fixed effect of region on wage).

[18] The effect is even greater when we exclude the residues from the 1990s regression.

Regression 2 examines how the wage in the researched region is affected by road investments in the main destination region of commuters from the researched region. This investigation is important both for the estimation of the total effect of road investment and to corroborate the existence of a causal relationship between improvement in transport infrastructures and an increase in wage. It is necessary to corroborate the existence of this connection due to the concern that an opposite relationship may exist—road investment in a region may be a result of regional economic development (and an increase in regional wages)—because the correlation *per se* gives no indication about the direction of the causality. Since there is no concern about investments in one region being affected by the economic situation in another region, Regression 2 may point to a causal relationship.

Table 3
Personal Wage in 2002–2004 as a Function of Personal Traits, Region of Residence Traits, and Region of Residence Road Investment

	1	2
Regional road investment	0.054 (0.011)	0.111 (0.011)
Road investment in main destination	—	0.227 (0.007)
Additional explanatory variables*	+	+
Observations (N)	21,502	21,502
R squared	0.2354	0.2724

* see Table A4 in the Appendix.

Regression 2 (in Table 3) resembles Regression 1. It, too, estimates men's wages on the basis of personal traits and natural region. The difference between it and Regression 1 is that four variables are added in Regression 2: road investment in the main destination region (for this purpose, we identified the main destination region of each origin region), road capital stock in the main destination region, area of the destination region, and population size of the destination region in 1993. We found that road investment in the main destination region contributed notably to the increase in wage in the origin region. The average road investment in the main destination region induced a 10 percent increase in wages in the researched region. Regression 2 yields a higher contribution of road investment in a region to wages in that region than does? Regression 1. On the basis of the different specifications, we may estimate that investing in roads at a level equal to the average investment per natural region in 1992–2004 ($ 66 million at 1995 prices) in the researched region and in its main destination region boosted wages in the researched region by 10–14 percent. By estimation, then, total road investment in 1992–94 raised the total national wage at a similar rate—not including the contribution of investment in secondary destination regions, as stated.

In addition to examining the effect on the wage, we also examined the effect of road investment on the rate of employment in the district. We found that increased road investment in the district of origin had a negative but non-significant effect on the employment rate. Such investment in the main destination district, on the other hand, had a statistically significant positive, but minimal, effect on employment. In our view, the change in demand for labor impacts mainly on the wage, and hardly, if at all, on employment. The variation in employment rates derives mainly from other causes, such as long-term demographic changes, welfare policy, and the minimum wage.

6. CONCLUSION

This study examined the effect of land transport infrastructure investments on commuting patterns in Israel by using the gravitation model. The gravitation model estimated commuter flows between origin–destination region pairs as a function of the size of the economies of the origin and destination regions, the geographical distance between the regions, the past commuter flows and infrastructure investments in the two regions.

The results of the gravitation model show that the commuter flow between origin region and destination region increased in response to an upturn in road investment in the origin region and in the destination regions, and it also increased in response to investment in railroad system. The model did not reveal the effect on commuter flow of investment in crossed regions, those situated between origin region and destination region. According to the model, total infrastructure investment in 1992–2004 explains about two-thirds of the total increase of 240,000 commuters. The sensitivity analyses indicate that rail investment (which boosted the number of commuters by 18,000) made most of its contribution in regions that were relatively far from each other (non-contiguous). Road investment, in contrast, enhances commuting mainly between contiguous national regions but makes no real upward contribution to commuting between regions that are farther apart. Infrastructure investment exerted more of an upward effect on men's commuting than on women's commuting.

Another important outcome of the study concerns the effect of road investments on men's wages. We found that the mean road investment in a given natural region and its main destination region raised wages in the region at issue by 10–14 percent. Accordingly, one may estimate that the total road investment in 1992–2004 raised the average wage by a similar magnitude, if not by more because the study excluded the contribution of investments in secondary destination regions.

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Appendix Table 1
Commuting and Road Investment in Natural Districts, Main Data
(NIS million, at 1995 prices)

	Outgoing commuting		Incoming commuting		Population 1993	Region area (sq. km.)	Region road capital stock2004	Road investment 04-92
	2003	1993	2003	1993				
Judean Mountains	7.9	5.2	19.9	8.2	432.9	316	1.67	173.1
Judean Foothills	9.1	3.6	2.9	1.5	31.4	337	1.01	52.2
Hula Basin	1.6	0.9	3.5	2.8	30.9	232	0.65	132.8
Eastern Upper Galilee	2.1	1.3	3.2	2.5	34.2	336	1.18	179.6
Hazor Region	1.6	1.1	1.6	1.1	16.3	102	0.33	95.4
Kinnerot	1.9	1.1	5.7	4.9	51	191	0.89	16
Eastern Lower Galilee	3.7	2.6	1.6	1.7	30	338	0.97	57.7
Bet She'an Basin	1.3	0.8	2.9	1.2	24.5	217	0.56	0
Harod Valley	1.5	0.7	1.5	1.2	13.6	106	0.36	0
Kokhav Plateau	1.2	0.6	0.5	0.2	8.0	154	0.30	0
Yizre'el Basin	4.9	2.5	9.2	7.2	49.9	297	1.06	291.4
Yoqne'am Region	5.3	3.1	6.0	2.3	16.8	61	0.32	201
Menashe Plateau	0.1	0.3	0.8	0.5	4.3	102	0.19	32.3
Nazareth-Tir'an Mountains	22.7	19.7	8.6	4.1	208.3	256	0.89	246.1
Shefar'am Region	18.1	16.7	2.6	1.1	118.7	249	0.58	53.8
Karmi'el Region	9.0	7.6	6.2	3.5	71.8	107	0.38	62
Yehi'am Region	7.2	4.6	4.1	2.5	56.8	240	0.61	149.5
Elon Region	2.2	1.1	0.7	0.5	12.6	136	0.59	19.1
Nahariyya Region	9.7	5.4	7.9	5.4	65.5	99	0.54	103
Akko Region	8.0	6.3	7.4	7.3	63.6	97	0.47	145.1
Northern Golan	1.2	0.9	0.3	0.1	10	479	0.89	0
Southern Golan	0.2	0.5	0.2	0.2	4.6	281	0.49	0
Haifa Region	22.7	13.9	43.3	36.8	478.7	294	1.76	145.2
Hof HaKarmel	2.7	3.4	2.1	1.0	16.3	74	1.01	0
Zikhron Ya'aqov Region	2.6	0.6	2.1	1.5	11.4	138	0.29	135.2
Alexander Mountain	10.0	6.4	0.6	0.3	64.8	125	0.35	95.1
Hadera Region	18.5	9.6	13.2	7.9	134	235	1.55	105.4
Western Sharon	29.8	19.2	21.3	10.4	202.5	261	1.51	391.2
Eastern Sharon	9.3	6.9	1.2	0.4	57.5	87	0.48	100.5
Southern Sharon	44.4	33.3	25.5	12.1	168.8	124	1.10	729.8
Petah Tiqwa Region	51.8	36.7	49.1	25.9	234.1	159	1.39	652.6
Lod Region	38.7	18.6	35.8	32.4	149	339	2.18	564.5
Rehovot Region	31.2	18.9	24.5	11.3	146.9	207	1.33	262
Rishon LeZiyyon Region	56.1	34.9	30.1	16.4	179.3	117	1.24	122.7
Tel Aviv Region	54.8	37.6	214.6	188.9	469.3	94	1.17	965.1
Ramat Gan Region	66.7	61.7	61.9	45.3	359.1	40	0.52	125.3
Holon Region	73.1	75.0	25.5	17.6	311.7	38	0.39	234.7
Mal'akhi Region	6.7	3.5	7.1	2.6	40.6	323	0.85	35.4
Lakhish Region	5.5	2.4	4.5	1.9	47.1	483	1.01	60.9
Ashdod Region	22.1	8.3	10.5	7.7	110.3	52	0.07	548.6
Ashqelon Region	10.0	5.1	7.5	2.6	100.5	408	1.24	129
Gerar Region	1.8	1.3	1.8	1.1	24.5	317	0.86	106.8
Besor Region	2.5	1.6	1.7	1.1	33.2	1081	1.26	334.4
Be'er Sheva Region	10.1	6.5	7.0	4.2	255.6	2,006	2.69	309.4
Northern Negev Mountains	1.5	1.1	4.5	3.5	44.9	4,820	3.21	125.2

Appendix 2
Highway 6 (Cross-Israel Highway)

Highway 6 is a toll road built and operated by a private entity; the cost of construction did not constitute part of the State budget. The central section of the highway, between Soreq and Iron, was opened in 2004. To examine its effect on commuting, we used 2004 commuting data relative to the average extent of commuting from 1999 to 2001 (henceforth "2000"). We used the gravitational model and specifications similar to those in Table 2. We deleted the variables of road and rail investment from the specifications in Appendix Table 2, and added a dummy variable for Highway 6, which was given a value of 1 if the highway was in both the district of origin and the destination district, and the value 0 otherwise. In regressions 1–3 there was a significant increase in commuting by men aged 20–55 years in the districts connected by the highway. In regression 4 the highway was not found to increase commuting among all workers aged 20–65, but deleting the non-significant road capital stock variables (Regression 6) enabled us to reject the null hypothesis at the 10% significance level. The coefficient of the Highway 6 dummy variable in Regressions 4 and 5 was not bigger than that in Regressions in 2 and 3, leading to the conclusion that the highway increased commuting among men aged 20–55 but not among the complementary group. With regard to the total quantitative effect of the highway, it created forty-two links between districts of origin and destination districts, leading to the assessment that it added 4,200 to the number of commuters. The highway's total effect on commuting is expected greater than that, as it was measured here shortly after it opened, and commuting patterns change gradually.

Appendix Table 2
The Effect of the Cross-Israel Highway (Highway 6) on Commuting
Explained Variable—the Number of Commuters from Origin to Destination in 2004

	Men aged 20–55			Men and women aged 20–55	
Regression	1	2	3	4	5
Dummy variable for district pairs with Highway 6	84.1 (25.0)	92.3 (39.8)	109.4 (39.5)	98.6 (62.6)	102.8 (62.5)
Commuters in 2000	0.88 (0.006)	0.89 (0.006)	0.89 (0.006)	0.93 (0.005)	0.93 (0.005)
Workers in destination district in 2000	0.0009 (0.0002)	0.0009 (0.0002)	0.0010 (0.0002)	0.007 (0.0002)	0.0008 (0.0002)
Population increase in destination district 2000–2004	0.018 (0.004)	0.018 (0.004)	0.019 (0.004)	0.019 (0.003)	0.019 (0.002)
Population increase in origin district 2000–2004	-0.002 (0.004)			0.004 (0.003)	0.006 (0.003)
Distance (km)	-3.48 (0.63)	-3.39 (0.63)	-3.23 (0.62)	-7.37 (0.90)	-7.35 (0.90)
Distance squared	0.015 (0.004)	0.014 (0.004)	0.014 (0.004)	0.032 (0.005)	0.032 (0.005)
Destination road capital stock	39.1 (17.9)	32.2 (12.5)		30.8 (21.0)	
Road capital stock in origin district	35.7 (16.2)	20.2 (12.1)		-2.5 (20.2)	
Size of destination natural district	-0.02 (0.02)				
Size of origin natural district	-0.007 (0.017)				
Constant	78.4 (25.0)	87.9 (24)	126.9 (20.4)	209.3 (36.4)	228.2 (31.0)
No. of observations	921	921	921	1,082	1,082
R^2	0.970	0.970	0.970	0.982	0.982

Figures in parentheses are standard deviations.

Appendix Table 3
The Effect of Road and Rail Investment on Commuting between Origin and Destination
Explained Variable—the Average Number of Commuters 2002–2004

	1	2	3	4	5	6
	Total sample	Total sample	Total sample	Men commuters	Women commuters	Excl. Modiin[a]
Dummy for connection to railway	141.7 (56.1)	179.2 (56.7)	117.2 (56.3)	104.3 (38.3)	42.3 (36.2)	145.2 (56.0)
Road investment in origin	0.444 (0.087)	0.540 (0.090)	0.350 (0.093)	0.262 (0.058)	0.284 (0.057)	0.431 (0.085)
Road investment in destination	0.259 (0.102)	0.592 (0.086)	0.211 (0.103)	0.223 (0.067)	0.061 (0.070)	0.241 (0.100)
Origin–destination commuters, 1993	0.959 (0.008)	0.958 (0.008)	0.957 (0.008)	0.825 (0.009)	1.124 (0.011)	0.958 (0.008)
Origin–destination distance (km)	-16.9 (1.40)	-16.7 (1.41)	-17.6 (1.40)	-11.1 (0.98)	-9.8 (1.00)	-15.9 (1.39)
Distance squared	0.077 (0.008)	0.075 (0.008)	0.079 (0.008)	0.051 (0.006)	0.045 (0.006)	0.072 (0.008)
Origin population growth	4.234 (0.688)	--	4.000 (0.722)	3.055 (0.464)	1.984 (0.470)	3.980 (0.715)
Destination population growth	1.546 (0.664)	--	1.536 (0.701)	1.000 (0.437)	0.817 (0.478)	1.499 (0.658)
No. of employed in destination in 1993	0.0019 (0.000)	0.0001 (0.0006)	0.0019 (0.0003)	0.0021 (0.0003)	0.0028 (0.0005)	0.0017 (0.0003)
Destination population in 1993	--	0.970 (0.252)	--	--	--	--
Origin population in 1993	--	0.410 (0.148)	--	--	--	--
Average age in destination	--	--	-5.74 (12.99)	--	--	--
Average years of education in destination	--	--	33.6 (94.55)	--	--	--
Proportion of Jews in destination	--	--	230.5 (121.0)	--	--	--
Average age in origin	--	--	-25.08 (13.9)	--	--	--
Average years of education in origin	--	--	-0.14 (92.6)	--	--	--
Proportion of Jews in origin	--	--	342.6 (119.4)	--	--	--
Constant	365.2 (51.2)	290.1 (58.2)	1122.9 (705.6)	230.3 (34.6)	191.8 (34.5)	353.8 (50.7)
No. of observations	1,117	1,117	1,117	999	711	1,087
R^2	0.951	0.950	0.951	0.936	0.954	0.953

[a] Excluding origins and destinations both of which are in the Tel Aviv or central conurbation.

Figures in parentheses are standard deviations.

Appendix Table 4
Personal Wage in 2002–2004 as Function of Personal Traits, Region of Residence Traits, and Region of Residence Road Investment

	1	2	3
Road investment in region	0.054 (0.011)	0.111 (0.011)	0.081 (0.011)
Road investment in main destination	—	0.227 (0.007)	0.190 (0.006)
Region of residence: mean region residue from 1992–1994 wage regression	1.38 (0.16)	0.92 (0.16)	1.21 (0.16)
Region population in 1993	–0.0003 (0.0001)	0.0005 (0.0001)	-0.00003 (0.0001)
Region area (sq. km.)	–0.020 (0.005)	–0.039 (0.007)	-0.005 (0.006)
Region road capital stock	15.7 (5.03)	3.5 (5.1)	-8.73 (5.03)
Dummy for rail connection	1.9 (7.4)	27.3 (7.6)	9.5 (7.5)
Main destination population in 1993	—	–0.00035 (0.00017)	-0.0016 (0.0001)
Main destination area	—	–0.084 (0.007)	0.0001 (0.003)
Main destination road capital stock	—	155.9 (11.9)	--
11–12 years of schooling	82.1 (6.3)	64.6 (6.1)	66.2 (6.1)
13–15 years of schooling	177.4 (6.8)	158.8 (6.6)	161.0 (6.6)
16 years of schooling	340.1 (6.7)	316.9 (6.6)	319.9 (6.6)
Age 25–34	–119.0 (6.7)	–114.3 (6.6)	-114.6 (6.6)
Age 35–44	–35.6 (6.7)	–28.3 (6.6)	-28.6 (6.6)
Age 45–54	11.3 (6.8)	12.6 (6.7)	13.6 (6.7)
Dummy for Jewish	82.8 (7.8)	74.4 (7.8)	57.3 (7.7)
Dummy for Asian-African origin	–29.4 (4.9)	–33.0 (4.8)	-33.0 (4.8)
Dummy for immigrant	–146.8 (6.3)	–174.4 (6.3)	-169.5 (6.3)
Dummy for 2002 survey	133.9 (5.0)	71.1 (5.3)	80.4 (5.2)
Dummy for 2003 survey	117.5 (5.1)	56.2 (5.3)	66.5 (5.2)
Constant	142.5 (9.9)	115.3 (14.6)	221.8 (12.2)
Observations (N)	21,502	21,502	21,502
R squared	0.2354	0.2724	0.2658

Appendix 5

Map of Natural Districts and Population Density in Israel