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WORK TRIP CHARACTERISTICS FOLLOWING THE GULF CRISIS: THE EXPERIENCE IN AMMAN, JORDAN

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ABSTRACT: This paper investigates the home to work trip characteristics following the Gulf crisis and the huge influx of Gulf returnees (mainly from Kuwait). These characteristics are measured through specifying and estimating three disaggregate models. These models represent the commuters' home to work trip duration, the frequency increase with which commuters arrived late at work, and the delay duration increase following the Gulf crisis. The specified models were estimated through the use of a random commuter survey carried out in Amman, Jordan's capital. The results show that, on average, commuters now arrive late at work three times a week compared with about once a week before the crisis. Furthermore, there is a clear shift in commuters' departure time. More commuters are departing earlier now (following the crisis) to compensate for the effect of traffic congestion. This clearly demonstrate the impact of the Gulf crisis and inability of the current transportation services to handle the new demand. Estimation results clearly suggest that commuters' household location, home to work mode choice, home departure time, work location, and the socioeconomic characteristics influence greatly the home to work trip characteristics. Elasticity estimates show that only the work trip length has an elasticity greater than one. Thus, the likelihood of arriving late at work and the delay duration are dominated by the level of congestion faced by commuters.

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1. Introduction

Since the Gulf crisis started, the transportation system in the Greater Amman in particular and Jordan in general has witnessed significant changes in commuter trip patterns. In the early stages of the crisis, people had the tendency to "bulk shop" and stayed at home longer (hence fewer away-from-home trips). Furthermore, the decision by the Government to ration fuel during the Gulf crisis has forced commuters to shift from private vehicles to other available modes and reduced the number of out-of-home activities. One of the most serious problems that faces Amman, Jordan's capital, is the heavily congested traffic network. Traffic congestion intensified following the Gulf crises and the huge influx of returnees.

Around 350,000 Gulf returnees have settled in Jordan, the majority coming from Kuwait. This number represents 10% of the total population. The majority settled in the greater Amman area. The sudden and significant increase in Amman's population has generated new demand for travel. The returnees have brought with them over seventeen thousand private vehicles (about 4% of the total number of registered vehicles). This increase in the number of private vehicles alone is not high enough to cause major disruption to the traffic network. However, given the already saturated urban streets and arterials, any marginal increase in traffic is a significant influence on traffic congestion. As part of their settling process, the returnees had to carry out a greater number of away-from-home activities. On the supply side of the problem, no new facilities were constructed or made available to meet the new demand.

Apart from the saturated and heavily congested arterials, there were certain routes which enjoyed little capacity. In the light of the recent developments, most routes and nearby intersections

reached their capacity during the peak periods. Arterials that pass through low to medium income areas were the ones that were heavily congested most of the time. This can be attributed to the settling of a significant number of returnees in medium income areas, and to the commercial orientation of these arterials which offer all types of retail employment.

The work force has witnessed significant delays and higher travel times on the way to work. This has occurred after the operational state of the traffic stream on most streets and major arterials has been degraded. Employers began witnessing very frequent late work arrivals by their employees. Descriptive statistics show that 23.5% of commuters had arrived late at work in the past week compared with 9.23% before the crisis. Furthermore, the average frequency of arriving late at work increased to 2.78 from 1.28 per week. The average work trip length has also registered a significant increase after the crisis. Statistics show that the average work trip length has increased from 18.2 minutes before the crisis to 27.41 minutes after the crisis. Figure 1 shows the work trip length distribution before and after the Gulf crisis. The graph clearly shows that more commuters are experiencing higher travel times.

The Gulf crisis has also affected the commuters' departure time. Figure 2 shows the shift in commuters' departure time following the crisis. More commuters are departing earlier, particularly between 6:00am and 7:30am. Peaking characteristics are more pronounced when compared to the departure time distribution before the crisis. The shift in commuters' departure time shows the responsiveness of commuters to traffic congestion.

The objective of this paper is to shed some light on the home to work trip characteristics following the Gulf crisis and the huge influx of returnees. In this paper, these characteristics are measured by specifying and estimating disaggregate models for the commuters' work trip length, frequency with which commuters arrive late at work, and above of all, the delay duration. For the purpose of this paper, the delay duration for a particular commuter will be defined as the planned arrival time compared to the actual time. Thus a commuter starting work (or arriving at work) on time will have zero delay duration. All this will be studied in light of the huge influx of returnees from the Gulf area.

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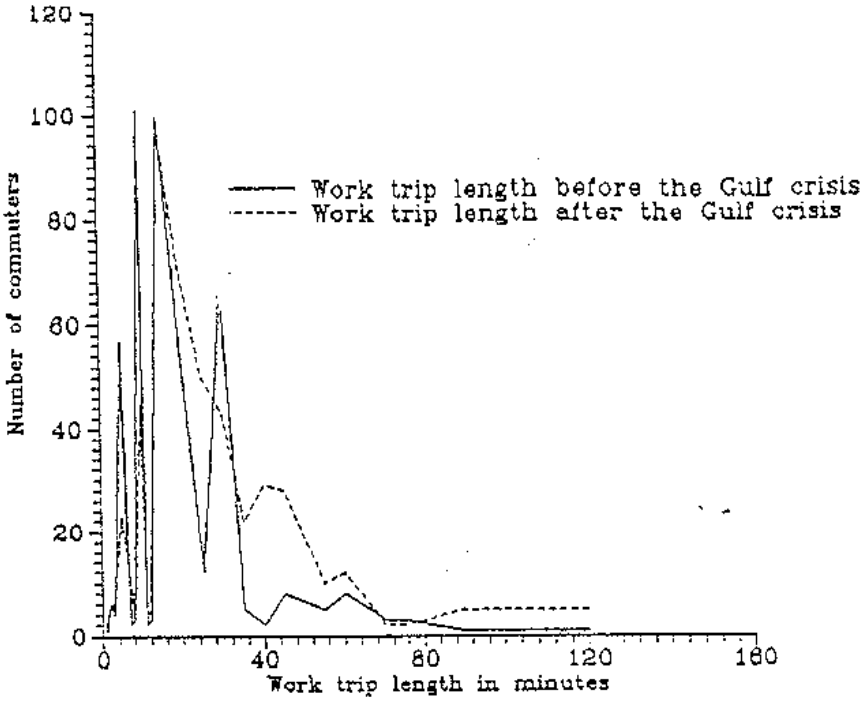

Figure 1. Commuter work trip length distribution before and after the Gulf Crisis

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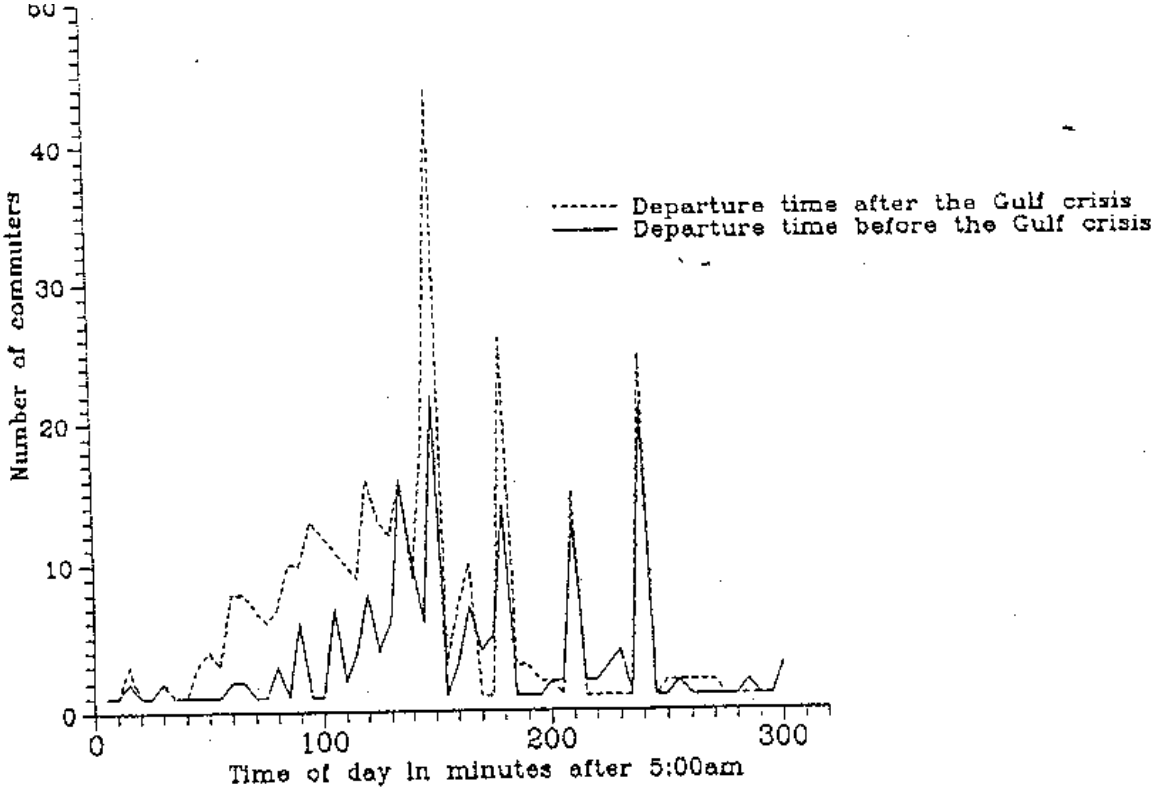

Figure 2. Commuter departure time distribution before and after the Gulf Crisis

2. Home to Work Trip Duration Model

The work trip length is usually influenced by the traffic system (level of congestion, availability of alternative routes, and duration of traffic congestion), the commuter's socioeconomic characteristics, presence of activity opportunities before work arrival, and travel choices (e.g., travel mode choice, departure time). It has been argued that commuters have control over their travel time since they are able to alter driving speeds, risk taking behaviour, and reaction times (Mannering et al., 1990). This kind of control however is only available when the transportation network is not under extremely congested conditions.

Abkowitz (1981), estimated a departure time model for work trips. The estimated model explicitly accounts for the arrival time uncertainty and the commuter perceived loss associated with varying arrival times. The reader is referred to work in this area by Abu-Eisheh and Mannering (1988), Mannering (1988), Ben-Akiva, de Palma, and Kanaroglou (1986), Mahmassani and Chang (1985, 1986), Small (1982), and Hendrickson and Kocur (1981). The following continuous identity forms the basis of the average travel time from home to work:

$$HWTT_r = \beta_0 + \beta_1 SOC_r + \beta_2 TRAFS_r + \beta_3 TC_r + \varepsilon_r \quad (1)$$

where $HWTT_r$ is the average home-to-work travel time in minutes for commuter r, SOC_r is a vector representing the commuter's r socioeconomic characteristics, $TRAFS_r$ is a vector representing the traffic system, TC_r is a vector of travel choices (travel mode choice, departure time), β's are estimable parameters, and ε_r is a disturbance term.

3. Frequency Model of Late Work Arrivals

In addition to modelling the work trip length, it is beneficial to develop for those commuters indicating that they arrived late at work, a model of the frequency with which they arrived late (conditional frequency). It is hypothesised that the work trip length, resulting partly from random fluctuations in traffic congestion experienced by commuters, influence the frequency of arriving late at work. As such, the expected work trip length estimated by equation (1) will enter this model as an explanatory variable.

The mean and the variance of the frequency distribution for those commuters who arrived late at

work were very close. This makes the data set well suited for Poisson regression analysis (see Lee 1986, Hausman et al. 1984, and Mannering 1988). The Poisson model can be stated as:

$$P(K_r) = [\exp(-\lambda_r)\lambda_r] [(K_r)!]^{-1} \quad (2)$$

where $P(K_r)$ is the probability of commuter r arriving late at work k times per week and λ_r is the Poisson parameter for commuter r and defined as

$$\ln(\lambda_r) = \gamma Z_r \quad (3)$$

where Z_r is the disutility derived from arriving late at work and γ is an estimable coefficient. From equation 2, the Poisson regression likelihood function can then be stated as:

$$L(\gamma) = \prod_r [[\exp [-\exp (\gamma Z_r] [\exp (\gamma Z_r)]^{K_r}](K_r)!]^{-1}] \quad (4)$$

4. Delay Duration Model

The final part of the modelling system is the development of a model of the average delay duration (planned arrival time compared to actual time) increase following the Gulf crisis for those commuters who arrived late at work. Employees have frequently been either penalised or fired because of late arrival at work. To avoid such penalties some commuters have adjusted their home departure time in the hope of arriving at work on time. The commuter survey showed an average delay duration increase was 9.21 minutes. By any standard, this figure is quite high and clearly reflects the frustration of working and non-working individuals.

From the observed data one can see that we have a censored dependent-variable problem, in that the commuter's delay duration is either zero or a positive, real number. In the case of zero, this means that the commuter arrived at work on time (no delay)[1]. The censored regression model is an obvious choice for this problem (see Tobin (1958)). The major premise in the censored regression model is the explicit account for situations in which some observations are lost beyond a specific limit or range. The delay duration (Dd) in minutes can be defined as,

[1]This rules out the use of least squares estimation method, since the assumption of linearity no longer exists (see Amemiya, 1984).

$Dd_r = 0$ never late (on time)
$Dd_r = Dd'_r$ $Dd'_r > 0$ late work arrival

where Dd'_r is a positive real number representing the delay duration in minutes for commuter r. The standard Tobit model can be written as:

$$Dd'_r = Z'_r\gamma + \delta_r \qquad (5)$$

with

$Dd'_r = Dd'_r$ if $Dd'_r > 0$

$Dd_r = 0$ if $Dd'_r \leq 0$

where Z_r is the set of explanatory variables, γ is a vector of estimable parameters, and δ_r an error term assumed to be independent and identically distributed (i.i.d.) drawings from the normal distribution. Again, it is hypothesised that the work trip length is expected to play a dominate role in determining the delay duration. As such, the expected work trip length will enter this model as an exogenous variable. The likelihood function of the censored model can be written as:

$$L(\gamma) = \prod_o [1 - \theta (Z_i\gamma/\sigma)] \prod_1 \sigma^{-1}\phi[(Dd_r - Z_i\gamma)/\sigma] \qquad (6)$$

with the log-likelihood function given as:

$$\log(L(\gamma)) = \sum_o \log[1 - \theta (Z_i\gamma/\sigma)] - (n_1/2)\log\sigma^2 - (1/2\sigma^2)\sum_1 [(Dd_r - Z_i\gamma)^2 \qquad (7)$$

where θ and ϕ are distribution and density functions of the standard normal respectively, $\prod_o$ and $\prod_1$ represent the product over those commuters for which $Dd'_r \leq 0$, $Dd'_r > 0$ respectively, and σ^2 is the variance of the error term.

5. The Empirical Setting

There are five main modes of transportation responsible for the mobility of commuters from home to work in the greater Amman area. These modes are 1) privately owned vehicles, 2) public buses, 3) Taxi cabs, 4) service taxis, and 5) private buses. Each mode has its own operational characteristics and thus captures certain segment(s) of the population. Public buses within the greater Amman area are owned and operated by the Public Transport Corporation. The fleet consists of 300 buses. The Corporation operates a flat fare system, with each route having a fixed fare. There are no scheduled stops between terminals. The waiting and transfer times associated with the bus fleet are very high due to the poor service frequency.

Private buses are owned and operated by private firms or individuals. These buses operate on fixed routes with a fare system regulated by the government. On low demand routes, the transportation services provided by these buses do not follow any pattern, causing on balance a great deal of inconvenience to the bus user. There are no scheduled stops between terminals.

Taxi cabs are privately owned and operated. These taxis are metered and regulated by the local government. There are about 5000 taxi cabs in the Amman area. One operational characteristic of these taxis worth noting is that most taxi cab drivers traverse the Amman area for the purpose of picking up passengers. They rarely stay in their designated offices to respond to demand through telephone calls. To curtail the presence of taxi cabs on the traffic network, the local authority requires each driver to pick up a two-hour permit from his office. After that, the taxi cab driver must return to the office and collect another permit. This strategy has not curtailed the presence of taxi cab drivers on the traffic network. Commuters are still not used to calling the taxi cab offices to ask for taxi service. One can see clearly the side effects of these taxi cabs on the traffic network most of the time. In the light of the recent huge influx of returnees, the demand on taxi cab services increased significantly and taxi cab drivers can hardly cope with the new demand.

2600 service taxis in the Amman area provide a significant amount of the public transportation services. These taxis are privately owned and operated on fixed unscheduled routes with no scheduled stops between terminals.

A random sample of 450 commuters were surveyed in the greater Amman area in June of 1992 to obtain suitable data for estimating the trip duration, frequency and delay duration models. Table 1 shows a summary of the commuting patterns and socioeconomic characteristics. The average

home to work trip duration is 19.48 minutes. 23.45% of commuters have arrived late at work in the past week with an average increase in delay duration of 9.21 minutes. The average number of times (frequency) that commuters arrived late at work following the Gulf crisis increased to 2.78 times per week from 1.28 prior to the crisis. Socioeconomic characteristics reported are typical for the greater Amman region commuters.

6. Estimation Results

The commuter's work trip length turned out, as expected, to be a function of the transportation network characteristics, the transportation mode chosen, and the commuter's socioeconomic characteristics. Both commuters' work trip mode and home departure time were included in the travel time model and considered as exogenous variables. This is because travel time is determined by both commuters' mode choice and home departure time, which makes it endogenous. The parameter estimates shown in Table 2 indicate that the commuter's home to work trip length is expected to increase if the work trip mode selected was the service taxi or the bus. This finding is generally true particularly if we know that both public buses and service taxis have no scheduled services. The transportation services offered by these two modes are not reliable most of the time, particularly after the Gulf crisis. The lack of reliability in the case of service taxis is mainly due to the operating nature of these taxis. They operate on the basis of 100% passenger occupancy, and as such that they will never depart the originating terminal unless they are 100% loaded. The number of service taxis on each fixed route can vary considerably within the day and from day to day, since they are privately owned and operated. It should be pointed out that because of the high influx of the Gulf returnees, the demand for bus and service taxi services increased significantly. Long queues at bus and service taxi stations became the norm. The supply of more transportation services, on the other hand, remained unchanged.

Table 1. Summary of sample* statistics (averages unless otherwise noted)

Variable	
Age of respondent in years	42.16
Gender of respondent - percent male	86.6
Number of children under 5-years of age in household	3.23
Annual household income (Jordan Dinars**)	4620
Marital status - percent married	80.9
Number of employed persons in household	1.62
Number of cars in household	1.35
Number of dependents in household	5.10
Home to work trip length in minutes following the Gulf crisis	19.48
Percent of respondents who suffered increased late work arrival in the past week following the Gulf crisis	23.45
Frequency increase in late work arrival per week following the Gulf crisis	2.78
Increase in delay duration following the Gulf crisis in minutes	9.21
* sample size: 450 observations	
** one Jordan Dinar = $US1.47 (approximately)	

Table 2. Ordinary least squares estimation results of home to work trip length following the Gulf crisis, t-statistics in parentheses

Dependent Variable: Log(trip length) Variable	Estimated Parameter
Constant	2.504 (13.09)
Household location (1 if household is located in district 9, 0 otherwise)	-0.206 (-3.15)
Work trip mode(1 if Service Taxi, 0 otherwise)	0.678 (7.88)
Work trip mode (1 if public bus, 0 otherwise)	0.564 (3.06)
Home departure time (1 if departure time is between 8:00-8:15 am, 0 otherwise)	-0.343 (-4.62)
Household income (1 if household income is less than 200.000 J.D. * per month, 0 otherwise)	0.436 (3.24)
Note: number of observations = 450, adjusted R-Squared = 0.23	

The commuter's household location plays a major role in determining the average home to work trip length. The results indicate that commuters located in the ninth district of the greater Amman area have shorter home to work trip lengths. This finding is very plausible, since this district has a share of 29% of the total Amman's employment (high employment attraction district). As such, the likelihood of a commuter living and working in this district is somewhat high (hence the shorter travel time). Since this district has a relatively high employment attraction index, commuters located outside this district are likely to experience high travel time to work.

Another variable representing the operational state of traffic stream on the traffic network is the commuters' home departure time. Commuters departing between 8:00am and 8:15am are likely to

experience shorter travel times to work. This reflects the state of low congestion on the traffic network at this time of the day.

Tables 3 and 4 depict the estimation results of the increase in frequency with which commuters arrive late at work and the delay duration increase following the crisis respectively. The results are very consistent with the general notions of activity-based analysis. Both Tables show that the work trip mode has a significant impact on the frequency of late arrival at work and delay duration. For instance, commuters choosing the private car as their mode of travel have a lower frequency of arriving late at work when compared with those who use the bus or service taxi (Table 3). Furthermore, commuters choosing the private car as their mode of travel are likely to have lower delay durations than those who use the service taxi or bus (Table 4).

Higher work trip length turned out to increase the likelihood of both arriving late at work and the delay duration (Tables 3 and 4). The work trip length variable was very significant in both models. Elasticity estimates for both models (Tables 5 and 6) show that only the work trip length has an elasticity greater than one. Thus, the likelihood of arriving late at work and the delay duration are dominated by the level of congestion faced by commuters.

Table 3. Poisson regression estimation results of the increase in frequency of late work arrivals per week following the Gulf crisis, t-statistics in parentheses

Variable	Estimated Parameter
Constant	-1.064 (-2.72)
Expected work trip length in minutes	0.504 (5.44)
Household income (1 if total household monthly income is greater than 600 J.D., 0 otherwise)	-0.102 (-1.71)
Work trip mode (1 if private car, 0 otherwise)	-0.326 (-2.57)
Age in years	-0.022 (-4.67)
Work location (1 if work is located in CBD area, 0 otherwise)	0.763 (6.30)
Note: number of observations = 106, log-likelihood at zero = -790.26, log-likelihood at convergence = -142.88	

Table 4. Censored Regression estimation results of the commuters delay duration increase in minutes, t-statistics in parentheses

Variable	Estimated Parameter
Constant	-18.775 (-4.40)
Work trip mode (1 if taxi cab, 0 otherwise)	-2.141 (-1.30)
Number of employed persons in household	-0.915 (2.34)
Total household monthly income in Jordan Dinar	-0.040 (-1.75)
Expected work trip length in minutes	0.538 (7.82)
Departure time from home (1 if between 6:00am and 7:00am, 0 otherwise)	5.135 (1.40)
Departure time from home (1 if between 8:00am and 8:15am, 0 otherwise)	-6.581 (-2.71)
Note: number of observations = 106, log-likelihood at zero = -838.36, log-likelihood at convergence = -587.41	

Table 5. Poisson regression elasticities estimated by sample enumeration

Elasticity with respect to	Elasticity
Expected work trip length	1.237
Age of commuter	-0.168

Table 6. Censored regression elasticities estimated by sample enumeration

Elasticity with respect to	Elasticity
Expected work trip length	1.308
Total monthly household income	-0.268
Total number of employed persons in household	-0.147

The results indicate that commuters working in the downtown area (district 1) are more likely to arrive late at work. This is not surprising, given the operational state of traffic in the downtown area. Furthermore, this district has the highest employment attraction. Socioeconomic factors turned out to play an important role in both models as seen in Tables 3 and 4. Commuters with distinctly different characteristics are expected to respond differently to traffic conditions. In households with high numbers of employed individuals, household members have lower delay duration (Table 4). It is expected that these commuters tend to carpool, leave home early, and, most importantly, avoid using public transportation services. The departure time significantly influences the delay duration (Table 4). Commuters departing from home during the peak period (7:00 am and 7:30 am) are more likely to have higher delay duration when compared with those who depart after the peak period (8:00 am and 8:30 am).

7. Concluding Remarks

In light of the recent developments in the Gulf area and the huge influx of returnees to Jordan, this paper has shed some light on the work trip characteristics. Three disaggregate behavioural models have been developed for this purpose. The results show that, on average, commuters arrive late at work three times a week with an average delay duration increase of 9.21 minutes. This highlights the inability of the current transportation services to handle the new demand for travel. The findings suggest that commuters' household location, home to work mode choice, and home

departure time play dominant roles in determining the home to work trip duration. In addition, the estimation results showed that both the frequency increase with which commuters arrive late at work and the delay duration increase are very much influenced by the choice of transportation mode, operational state of traffic stream, work location, and the commuter's socioeconomic characteristics. As expected, public buses and service taxis proved to lengthen the home to work trip length and to increase the frequency with which commuters arrive late at work. Elasticity estimates show that only the work trip length has an elasticity greater than one. Thus, the likelihood of arriving late at work and the delay duration are dominated by the level of congestion faced by commuters.

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