Estimating the effects of entry regulation in the Istanbul taxicab market

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Abstract
The economic literature shows that entry regulation in taxicab markets brings about a dramatic increase in medallion prices or license values of taxicabs. However, there is no study estimating what the effect of regulation is exactly on real medallion prices. We develop a model to estimate the effect of entry restrictions in the Istanbul taxicab market over real medallion prices and inflation. Our findings contribute that entry regulation in taxicab markets increases medallion prices. Moreover, we find that entry regulation in Istanbul pressures inflation rates as well.

1. Introduction

The economic literature has introduced two general approaches on the regulation of taxicab markets. The first approach includes theoretical points of view and a normative analysis deals with to understand how taxicab markets work and whether there are any features in the way taxicab markets work that would result in market outcomes not being economically efficient, resulting thus in some need for regulation. Insightful theoretical approaches have been proposed both for and against regulation (Cairns and Liston-Heyes, 1996; Beesley and Glaister, 1983; Williams, 1980; Coffman, 1977; Shreiber, 1975).

This is where the second approach begins. The second approach includes empirical studies and a positive analysis. Accordingly, the positive part of the literature has empirically investigated how different taxicab markets work around the world and has been certainly useful in understanding which theoretical perspectives on regulation are more valid. In this regard, many studies attempted to estimate the effects of regulation and deregulation in taxicab markets. While some of them investigate the existence of market failures such as economies of scale and externalities and the welfare effects of taxicab regulation (Yang et al., 2005; Hackner and Nyberg, 1995; Frankena and Pautler, 1984; Pagano and McKnight, 1983; Beesley, 1979; Eckert, 1970), others attempted to understand the role of deregulation on the market structure, prices and the quality of service such as changes in passenger waiting times and driver or vehicle standards (OECD, 2007; Schaller, 2007; Barrett, 2003; Marell and Westin, 2002; Morrison, 1997; Garling et al., 1995; Gallick and Sisk, 1987).2 Separately, Cumming (2009) investigates the role of unemployment rates, stock prices, population, and interest rates in determining the prices of taxi medallions.

In this context, this paper deals with a positive analysis of economic regulation in taxicab markets in the case of Istanbul. The paper empirically aims to reveal the effect of entry restrictions in the market over medallion prices. Although

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1 Tel.: +90 0224 2941000; fax: +90 0224 2941199.
2 Some of these studies include an analysis of the effects of both regulation and deregulation.
there are many studies exhibiting that regulation in taxicab markets gives rise to an increase in the medallion prices of taxicabs (Çetin and Öğüz, 2010; OECD, 2007; Moore and Balaker, 2006; Koehler, 2005; Barrett, 2003; Frankena and Pautler, 1984), there is no study that estimates empirically what the effect of regulation on medallion prices is. In this study, we empirically aim to estimate the effect of entry regulation on medallion prices by developing a model. In that sense, the paper is a first attempt.

A distinctive feature of the paper is that the findings of our study are coming from a large city outside of metropolitan cities in North America and Western Europe that consist of the existing literature. Since, most of the existing literature on the regulation of taxicab markets is focused on large cities in North America and Western Europe such as New York, Toronto, Washington, DC, (Cumming, 2009; Schaller, 2007; Rogoff, 1980), Chicago (Kitch et al., 1971), London (Beesley, 1979), Paris, Oslo, and Dublin (OECD, 2007), Istanbul includes similarities with the aforementioned cities in terms of population density. It is a metropolitan that has the largest population density in Turkey. On the other hand, an important feature of Istanbul is that the strict entry restrictions and the high medallion prices still continue.

According to Istanbul Transportation Master Plan (2007), taxis take only 5% share in all motorized trips in Istanbul. This number was over 10% in 1987. Whereas buses took 35% of total motorized trips in the city in 1987, the ratio is now 21.5%. The public transportation system still remains behind population and density growth. The limited availability of public transportation increases the demand for taxicab services.

The paper consists of three main sections after this introduction. In order to avoid going back and forth between description of the features of the market and opinions about regulation within the paper, it begins with a specific analysis of regulation and its effects in taxicab markets. Later, it introduces a detailed and comprehensive description of the Istanbul taxicab market.

In the third section, the paper aims to present empirical evidence into the literature over the regulation of taxicab markets. For this aim, we develop a model to estimate the effects of entry restriction over medallion prices and inflation in Istanbul. Our findings support that entry regulation effects on medallion prices and inflation rates in the case of Istanbul. The paper ends with a conclusion.

2. The rationale for regulation and deregulation in taxicab markets

The fundamental structure of taxi regulation is the same in almost all big cities of the world. Regulation in taxicab markets roughly includes quantity restrictions (entry regulation), fare settings (price regulation) and quality controls (social regulation) (Teal and Berglund, 1987: 37; Frankena and Pautler, 1984). Those who justify economic regulation in taxicab markets argue that barriers to entry are needed to ensure the efficient market outcomes. In a system of free entry, because taxis prefer to work in downtowns and make considerable demands on limited road resources, they give rise to negative externalities such as traffic congestion and pollution. In such cases, the social costs of taxi service will necessary exceed the price per ride. Economic efficiency requires that the social marginal cost of taxicab rides be equal to the price. If the price is below the marginal cost, this situation will bring about excessive use of taxicabs and negative externalities. To internalize negative externalities in taxicab markets, it is needed to regulate the price of using a taxi and to restrict the number of taxicabs. In that case, the presence of negative externalities is widely used as a reason for entry restrictions and price controls in taxicab markets (Yang et al., 2005; Shreiber, 1975: 274–275).

According to Heyes and Heyes (2007), another justification for regulation of entry stems from public good characteristics of taxis. If taxicab fares are relatively low, cabs can compose a close substitute for mass transportation (Shreiber, 1975, 275). When taxi service is thought as a public good, regulation is needed to provide taxi service to low demand rural areas timely and orderly.

Price control is another reason for state intervention to taxicab markets. There are impediments to price competition in taxicab markets (Frankena and Pautler, 1984). Unregulated taxicabs increase transaction costs considerably (Seibert, 2006, 71). Transaction costs to customers of finding a taxicab with the lowest fare in a competitive environment are high. When fares are not known beforehand due to information asymmetries, drivers may overcharge and abuse customers. In such cases, due to information asymmetries and transaction costs, the fare in an unregulated environment can be above or below the efficient level and fare controls can increase efficiency. In a regulated taxicab market, a predetermined price would give customers more information about the cost of a taxi ride and reduces haggling (Koehler, 2005, 52–53). As a result, entry and price regulation in taxicab markets is necessary to ensure the efficient market outcomes. However, it is generally accepted that the efficient market outcomes can be ensured only if entry and price regulation is simultaneously implemented (Cairns and Liston-Heyes, 1996).

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3 The ratio is 2420 people/km². The average of Turkey for cities is only 92 people/km².

4 It is possible to see that there are different segments such as taxi fleets, cabstands, and telephone orders within a market. One could offer different regulatory policies for these different segments of taxicab markets. However, our study does not include to analysis the outcomes of such a difference. See Teal and Berglund (1987), Williams (1980), and Coffman (1977) for detailed information about the different theoretical approaches for the different segments of the market.

5 According to a study, whereas taxicabs in the urban area of Hong Kong constitute about 25% of the overall traffic mix in some areas, this rate increases as much as 50–60% in some critical locations (Yang et al., 2005).

6 This reason for price control is valid especially in the case of cruising cabs and cabs using stands at airports.
All these approaches are discussed and criticized in the literature extensively (Shreiber, 1975; Coffman, 1977; Williams, 1980; Teal and Berglund, 1987; Bekken, 2007; Heyes and Heyes, 2007; Yang et al., 2010). Those who are against economic regulation and justify deregulation in taxicab markets argue that barriers to entry will result in an artificial rent over the selling prices of medallions by causing a monopolistic market structure. Accordingly, economic regulation in taxicab markets triggers a rent seeking process and brings about government failure (Moore and Balaker, 2006; Frankena and Pautler, 1984).

Generally, in the regulated markets, the artificial monopolistic structure and/or the regulatory process redirects entrepreneurial activities in the market to protecting rents, namely a high medallion value. This unproductive entrepreneurship is also destructive (Baumol, 1990). It makes more than wasting resources. Rent seeking reduces innovations in the market. In turn, rents are used to lobby the related administrative decision makers. It promotes the rent-seeking society. Entrepreneurs discover new ways of protecting rents at the cost of lower levels of quantity and quality (Laffont and Tirole, 1991).

As a result, an important consequence of entry restrictions is the lobbying activities of medallion owners. Both suppliers (i.e., consumers) and demanders (i.e., medallion owners) of monopoly rents waste some of their resources in the process (Tullock, 1967, 228). Medallion owners also have the advantage of the incumbent. Moreover, the regulatory process usually creates a vicious circle and gives way to more regulations. Regulators have a tendency to correct failing regulations with new ones.7

The failure of the taxicab regulation originates from the lack of necessary conditions for typical market failures. Taxicab market is not a natural monopoly8 and thus, it does not present a market failure condition. For that reason, regulation of entry and prices has negative effects and is unwarranted9 (Eckert, 1970; Beesley and Glaister, 1983; Frankena and Pautler, 1984; Moore and Balaker, 2006).

Although the empirical evidence is somewhat controversial, Moore and Balaker (2006), in a recent study, reviewed the results of studies on deregulation in taxicab markets. While 19 of 28 studies conclude that deregulation is good, 7 of studies say that deregulation is bad and 2 of them provide mixed results. Indeed, according to Frankena and Pautler (1984), many cities have successfully deregulated taxi markets and not experienced substantial market failures. Accordingly, it is possible to say that, along with deregulation movement, pro-regulation arguments lost some political support in recent times. Many deregulated markets eliminate entry and/or fare regulations (Barrett, 2003; Bekken, 2007). However, the elimination of entry regulation does not mean full deregulation in taxicab markets. Economic deregulation could be combined with social regulations. Thus, when social regulations with deregulation are strengthened, the quality of service in the market might increase.

3. The regulatory endowment in the Istanbul taxicab market

In Turkey, everyone who wants to become a taxicab driver must be a member of the Chamber of Drivers in that city. Moreover, entry and exit for the drivers into and from the market are free. In all cities, municipalities determine the number of taxicabs and taxi fares. 21 out of 81 cities have entry restrictions to taxicab markets. Other cities do not have any entry regulation due to the lack of demand. Taxi fares change across the country and regulated locally. Taxis are yellow colored and have the letter ‘T’ on their plate.

The market is only regulated through entry restrictions and fare regulations. Market conditions determine working hours and conditions. Apart from very general guidelines there are no strict rules that regulate the working conditions of the market. Taxis are free to cruise in the city. Some of them are also affiliated with taxi-stands, which also provide dispatching services. This does not stem from any regulation, but rather a choice of taxi drivers to reduce their cruising costs. In street corners and around shopping center, taxis establish taxi-stands and cruising. However, Pagano and McKnight (1983) argue that it is not possible to reveal empirically economies of scale only in dispatching, because most of taxis present all three types of service. Indeed, they find economies of scale only in small markets.

On the other hand, it is possible to say that price competition in the pure cruising cab situation is an alternative to the strict regulation of price.

7 Regulators reap the benefits of regulation: yet the costs are borne by the society. This creates an incentive for overregulation.

8 Frankena and Pautler (1984) reviews and concludes that there is some economies of scale in the dispatching segment of taxicab markets, but not in cab stands and cruising. However, Pagano and McKnight (1983) argue that it is not possible to reveal empirically economies of scale only in dispatching, because most of taxis present all three types of service. Indeed, they find economies of scale only in small markets.

9 On the other hand, it is possible to say that price competition in the pure cruising cab situation is an alternative to the strict regulation of price.
Lastly, the market is regulated by fare controls. The IMM regulates taxi fares through a transportation co-ordination committee. The committee determines initial fares and fares per km and declares a fare tariff annually or bi-annually. A taximeter calculates the price of each trip according to this fare tariff. Customers are charged on the basis of the distance they traveled and the time they spend in a taxi.

In a recent study, Çetin and Öğüz (2010) anecdotally analyzed the aftermaths of regulation in the Istanbul taxi cab market. They argue that the case of Istanbul has brought about the perils of bad regulation. Accordingly, the fundamental issue in Istanbul is entry regulation that continues since 1991. Although entry regulation is justified to reduce traffic congestion, the existence of approximately 20,000 taxis that work illegally in the market due to entry restriction disproves the effectiveness of the current regulatory structure.

According to Çetin and Öğüz (2010), the regulatory cycle gives rise to an artificial rent and triggers a rent-seeking society in the Istanbul taxi cab market. Medallion owners spend their resources to capture these rents, but not to engage in the productive discovery processes. The market is only regulated by entry restriction and fare controls of the IMM and medallion owners only engage into extract rent created by means of the medallion system.\(^\text{10}\)

A related issue concerning taxi fare regulation is tax-avoidance. According to the related tax laws in Turkey, incomes from both providing taxi services and medallion sales are liable to a lump-sum tax. Accordingly, taxi and medallion owners must declare their revenues to the tax authority at the end of every year and pay tax based on their revenue levels. However, neither medallion sales, nor taxi fares are de facto taxed in Turkey because taxi drivers and medallion owners tend to be dishonest in the disclosure of their revenues. Governments have failed to take this issue seriously.

4. Empirical method

In this section we empirically analyze the effects of entry restriction in the Istanbul taxi cab market within a Johansen et al. (2000) cointegration framework that takes into consideration structural breaks in the time series. For this purpose, we consider a vector autoregressive (VAR) system containing a group of endogenous variables those are taxi medallion prices, the number of taxi per thousand people and inflation. Before proceeding the cointegration analysis, however, it is appropriate procedure for investigating the univariate properties of the variables.

Minimum LM unit root tests with one break and two breaks proposed by Lee and Strazicich – hereafter LS (2003, 2004) seems to be an appropriate for investigating the univariate properties of the variables.

Minimum LM unit root tests with one break and two breaks proposed by Lee and Strazicich – hereafter LS (2003, 2004) are modified versions of Schmidt and Phillips (1992) unit root test by incorporating structural breaks(s) in mean Model A (Crash Model) and Model C (Changing Level and Growth Model), which were identified in Perron (1989). The LM unit root test can be obtained from the regression:

$$\Delta Y_t = d' \Delta Z_t + \psi \tilde{S}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta \tilde{S}_{t-i} + \eta_t \quad t = 1, 2, \ldots, T$$  \(\text{(1)}\)

where, \(Z_t\) is vector of exogenous variables, \(\tilde{S}_{t} = Y_t - \tilde{\psi}, t = 2, \ldots, T, \tilde{\psi}\) are coefficients in the regression of \(\Delta Y_t\) on \(\Delta Z_t, \tilde{\psi}_s\) is given by \(Y_{1} - Z_{1}\delta\) (see Schmidt and Phillips, 1992), and \(y_t\) and \(Z_t\) denote the first observations of \(y_t\) and \(Z_t\), respectively. The lag terms \(\Delta \tilde{S}_{t-i}\) are included to correct for serial correlation. Model A allows for shifts in level and is described by \(Z_t = [1, t, D_{10}, D_{20}]\) where, \(D_{10} = 1\) for \(t > T_{10} + 1, j = 1, 2, \text{and zero otherwise.} T_{10}\) denotes the time period when a break occurs. Model C includes two changes in level and trend and is described by \(Z_t = [1, t, D_{10}, D_{20}, D_{11}, D_{21}]\) where \(D_{10} = 1\) for \(t > T_{10} + 1, j = 1, 2\) and zero otherwise. The unit root hypothesis is tested via the \(t\)-ratio of \(\psi\), which being denoted as \(\bar{t}\), in Eq. (1). Denoting the break fractions as \(\delta_j = TB_j / T\), the LM unit root statistic can be defined as:

$$\text{LM} = \inf_{\bar{t}} \bar{t}(\bar{i}).$$ \(\text{(2)}\)

Critical values for Model A and Model B are given in Lee and Strazicich (2003, 2004). It should be noted that when there are no breaks in the series the critical values are the same as those in Schmidt and Phillips (1992).

Given the non-stationarity of the variables, we proceed with cointegration analysis in order to investigate the possibility of long-run relationship(s) among them. However, since Johansen (1988) cointegration procedure was not applicable in the presence of structural breaks in time series data, we use an alternative cointegration test proposed by Johansen et al. (2000), which is slight modification of VECM-based cointegration analysis.

Given that \(Y_t\) is a \(p\) dimensional vector of I(1) processes with \(r\) cointegrating relationships, the VECM, which was proposed by Johansen et al. (2000), can be written as:

$$\Delta Y_t = \xi [\beta'] [Y_{t-1} | E_t] + \mu E_t + \sum_{i=1}^{k} \Gamma_i \Delta Y_{t-i} + \sum_{i=1}^{k} \sum_{j=2}^{q} \Psi_i D_{j,t-i} + \sum_{m=1}^{d} \Phi_m W_{m,t} + \epsilon_t$$ \(\text{(3)}\)

where \(\Delta\) is the first difference operator; \(k\) is lag length; \(E_t = [E_{1t} \quad E_{2t} \quad \ldots \quad E_{rt}]\) is a vector of \(q\) dummy variables with \(E_{jt} = 1\) for \(t_{j-1} + k < t \leq T_j (j = 1, \ldots, q)\) and zero otherwise and the first \(k\) observation of \(E_{jt}\) is set to zero; \(E_{jt}\) is the effective sample

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\(^{10}\) See for a more detailed discussion about the aftermaths of regulatory process in the Istanbul taxi cab market Çetin and Öğüz (2010).
of the jth period. Dj,t,i is an indicator dummy variable for the ith observation in the jth period—that is Dj,t,i = 1 if t = Tj,i+1 (j = 2, . . . , q, t = . . . , −1, 0, 1, . . . ) and zero otherwise. Intervention dummies, Wm,i (m = 1, . . . , d), are included to render the residuals well-behaved, following Hendry and Mizon (1993). The β is the cointegrating vector, and represents the long-run relationship. And α is a vector representing the speeds of adjustment toward the long-run equilibrium. γ = [γ1, γ2, . . . , γq] is a matrix of (p × q) dimensional long-run trend parameters. The short-run parameters are μ of order (p × q), Γi of order (p × p) for i = 1, . . . , k, Ψji of order (q × 1) for j = 2, . . . , q and i = 1, . . . , k, and Φm of order (q × 1) for m = 1, . . . , d. The innovations εt are assumed to be independently and identically distributed with zero mean and symmetric and positive definite variance–covariance matrix Ω—that is εt ∼ iid(0, Ω).

Eq. (3), which is a linear trend model in which the trend and level of cointegration relationship shows a difference from period to period, is called as Hl(r). The likelihood ratio test against Hl(p) alternative r cointegration relationship Hl(r) hypothesis is:

\[
LR(H_l(r)|H_l(p)) = -T \sum_{i=r+1}^{p} \ln(1 - \hat{\lambda}_i)
\]

where \( \hat{\lambda}_i \) are squared sample canonical correlations and 1 ≥ \( \hat{\lambda}_1 \) ≥ . . . ≥ \( \hat{\lambda}_p \) ≥ 0.

In a cointegration relationship, there is no linear trend, but if only a breaking level exists, the model given in Eq. (3) can be transformed as in Johansen et al. (2000) and called as Hl(r). The critical values for either Hl(r) and Hl(r) models are derived from Γ − distribution, as proposed in Johansen et al. (2000).

Given the cointegration rank further restrictions on the VECM can be tested by likelihood ratio (LR) testing. Harris and Sollis (2003) took these tests in hand within a standard framework. In this study, LR tests are extended for the models that are proposed by Johansen et al. (2000) as in Dawson and Sanjuan (2005).

5. Data and empirical results

The data we used in this study are quarterly and cover the period 1989:4–2010:1. The variables under consideration are log of the number of taxis per thousand people (\( n_{\text{mp}} \)), log of real taxi medallion prices (\( p_{\text{mp}} \)), which were interpolated to obtain quarterly series from 1989:4 to 2006:4 using Baxter (1998) method, and consumer prices based inflation (\( \pi_{\text{mp}} \)) for Istanbul. The data was obtained from Central Bank of Republic of Turkey, Turkish Statistical Institute (TurkStat), TUBITAK (2007) and Bagcilar Oto Center.11 Fig. 1 presents the time graphs of the series.

According to Fig. 1, it can be said that while real medallion prices have a positive trend, the number of taxis represents a negative trend over time due to the entry restrictions. Additionally, after the Central Bank of Turkey began implementing an inflation-targeting regime in the beginning of 2002, inflation stabilized around single digit rates starting in 2004.

Before investigating the long-run relationships between the variables, in the study, we tested non-stationarity properties of the series in the presence of structural breaks using Lee and Strazicich (2003, 2004) minimum LM unit root test with one and two breaks. Unit root test results were reported in Table 1.

11 Bagcilar Auto Center is a central place for the medallion market. Some owners hold 80 to 100 medallions in their hands (Çetin and Oğuz, 2010).
Table 1 indicates that all variables are non-stationary in their levels. Additionally, Table 1 indicates that 1994:1 and 2000:3 were estimated as structural breaks for real medallion prices, which can be associated with 1994 and 2000–2001 economic crises in Turkey. Also, it can be clearly seen that 2000–2001 economic crises occurred as a structural break in inflation. Accordingly, the economic crises in 1994 and 2001 reduced medallion prices. After the recession, prices continued to rise. For the number of taxis per thousand people, however, we could not estimate any structural break. Fig. 2 represents the time graph of the series with structural breaks. The shaded areas in the diagrams cover the post-break and inter-break data. Structural breaks show that medallion prices are sensible to crises in the economy. The prices in which real medallion prices did not increase were years of economic crisis in 1994 and 2000.

Since the economic crises in 1994 and 2000–2001 estimated as structural breaks for taxi medallion prices and inflation, after investigating the non-stationarity of the series the analysis was extended by testing cointegration between the variables with the pair of breaks 1994:1–2001:1. The minimum value of Akaike Information Criterion (AIC) was adopted in order to select the optimum lag length and lag length was estimated as $k = 4$. Table 2 presents the results of Johansen et al. (2000) trace statistics for the pair of breaks 1994:1–2001:1.

Table 2 shows the two cointegrating vectors ($r = 2$) for the model $H_c(r)$, implying changes in level in the long-run. To choose the appropriate model here, the Pantula principle was applied, and because the residuals obtained from the models are normally distributed, intervention dummies were not required. The LR-statistics of the VECM restriction tests for were reported in Tables 3.

Fig. 2. Time series of the number of taxis per thousand people, real taxi medallion prices, and inflation for Istanbul with structural breaks (1990–2010).

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12 Pantula Principle provides a practical way to test the joint hypothesis of both the rank order and the deterministic components. In our analysis, both models are estimated and the results are presented from the most restrictive alternative (i.e. $r = 0$ and $H_l(r)$ model) through to the least alternative (i.e. $r = 3$ and $H(r)$ model). The test procedure is then to move through from the least restrictive model and at each stage to compare the trace statistic to its critical value and stop the first time the null hypothesis is not rejected (Harris and Solis, 2003). Therefore, $H_l(r)$ is chosen as appropriate model in this study.

13 Multivariate normality test statistics for skewness, kurtosis and joint are 2.79 ($p$-value = 0.25), 5.07 ($p$-value = 0.08) and 7.89 (0.09). These results imply that the model is normally distributed.
inflation. Allion prices have an inflationary pressure, with a 1% increase in real medallion prices resulting in a 0.32% increase in sand people results in a 0.71% increase in real medallion prices. For the inflation equation, we can say that real medallion prices in Istanbul. According to the estimates above, a 1% decrease in the number of taxies per thou-

\[ \begin{align*}
\text{ Identified Equations} & \quad \beta_{p,1} & & \beta_{p,2} & & \beta_{p,3} & & \mu_1 & & \mu_2 & & \mu_3 & & \chi_{p,1} & & \chi_{p,2} & & \chi_{p,3} & & \chi^2_{(2)} \\
\text{Medallion prices} & -0.71 & 1 & 0 & 4.07 & 4.43 & 5.17 & -0.06 & - & - & 2.65 \\
\text{Inflation} & 0 & 0.32 & 1 & 12.29 & 14.28 & 2.59 & - & - & -0.48 & p-value = 0.27
\end{align*} \]

### Table 2


<table>
<thead>
<tr>
<th>( H_0 ) ( { r } )</th>
<th>( \text{Model } H_0 { r } )</th>
<th>( \text{Model } H_{3} { r } )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r = 0 ) ( { r \geq 1 } )</td>
<td>63.80 (51.68)</td>
<td>87.83 (74.19)</td>
</tr>
<tr>
<td>( r = 1 ) ( { r \geq 2 } )</td>
<td>32.51 (32.25)</td>
<td>48.14 (47.99)</td>
</tr>
<tr>
<td>( r = 2 ) ( { r \geq 3 } )</td>
<td>11.70 (16.22)*</td>
<td>15.95 (24.74)</td>
</tr>
</tbody>
</table>

* Critical values in parentheses at the 95% confidence level can be approximated by \( T \)-distribution, as explained in Johansen et al. (2000).

** Denotes the first that the null is not rejected in Models \( H_{1} \{ r \} \) and \( H_{3} \{ r \} \).

### Table 3


<table>
<thead>
<tr>
<th>Null hypotheses</th>
<th>( H_0 )</th>
<th>LR-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual exclusion of:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n^p )</td>
<td>&amp;</td>
<td>7.67 (0.02)*</td>
</tr>
<tr>
<td>( \pi^m )</td>
<td>&amp;</td>
<td>11.08 (0.00)</td>
</tr>
<tr>
<td>( \pi^t )</td>
<td>&amp;</td>
<td>6.83 (0.03)</td>
</tr>
<tr>
<td>Weak exogeneity of:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( n^p )</td>
<td>&amp;</td>
<td>3.60 (0.16)</td>
</tr>
<tr>
<td>( \pi^m )</td>
<td>&amp;</td>
<td>9.67 (0.00)</td>
</tr>
<tr>
<td>( \pi^t )</td>
<td>&amp;</td>
<td>14.72 (0.00)</td>
</tr>
</tbody>
</table>

* Marginal significance levels are in parentheses.

Table 3 shows that, for the pair of breaks, each variable maintains in cointegration space. This implies that stationarities come from linear combinations of the variables with broken level. In addition, the lower panel of Table 3 shows that the number of taxies is weakly exogenous, while the others are endogenous.

Since two cointegrating vectors are established, at least two restrictions per cointegrating vectors are required for exact identification of the long-run relationships (Pesaran and Shin, 2002). In order to identify the long-run relationships, we employ the restrictions below in terms of economic expectations. Therefore, the long-run coefficient matrix for \( r = 2, q = 3 \) and \( H_1 \{ r \} \) is

\[ \begin{bmatrix}
\beta & \beta_{1,1} & \beta_{1,2} & \beta_{1,3} & \mu_1 & \mu_2 & \mu_3 \\
\gamma & \beta_{2,1} & \beta_{2,2} & \beta_{2,3} & \mu_1 & \mu_2 & \mu_3
\end{bmatrix} \]

(5)

In the restrictions matrix below, the first line of restrictions implies that inflation is set to zero in the taxi medallion prices equation. The second required restriction is \( \beta_{p,0} = -1 \), which indicates that real medallion prices is normalized. The second row normalizes inflation to negative one, with the number of taxies per thousand people constrained to zero:

\[ \begin{bmatrix}
\beta & -1 & 0 & \mu_1 & \mu_2 & \mu_3 \\
\gamma & 0 & \beta_{p,0} & -1 & \mu_1 & \mu_2 & \mu_3
\end{bmatrix} \]

(6)

By identifying the long-run equations correctly, these estimates can be interpreted as long-run elasticities (Johansen, 2005). Table 4 reports the identified long-run equations and identification test results.

It can be clearly seen from Table 4 that the price elasticity of taxi medallions with respect to the number of taxies per thousand people is ~0.71. There is a negative relationship between the number of taxies per thousand people and real medallion prices in Istanbul. According to the estimates above, a 1% decrease in the number of taxies per thousand people results in a 0.71% increase in real medallion prices. For the inflation equation, we can say that real medallion prices have an inflationary pressure, with a 1% increase in real medallion prices resulting in a 0.32% increase in inflation.

### Table 4

Identified long-run coefficient matrix and identification test results.

<table>
<thead>
<tr>
<th>Identified Equations</th>
<th>( \beta_{p,0} )</th>
<th>( \beta_{p,1} )</th>
<th>( \beta_{p,2} )</th>
<th>( \beta_{p,3} )</th>
<th>( \mu_1 )</th>
<th>( \mu_2 )</th>
<th>( \mu_3 )</th>
<th>( \chi_{p,1} )</th>
<th>( \chi_{p,2} )</th>
<th>( \chi_{p,3} )</th>
<th>( \chi^2_{(2)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medallion prices</td>
<td>-0.71</td>
<td>1</td>
<td>0</td>
<td>4.07</td>
<td>4.43</td>
<td>5.17</td>
<td>-0.06</td>
<td>-</td>
<td>-</td>
<td>2.65</td>
<td></td>
</tr>
<tr>
<td>Inflation</td>
<td>0</td>
<td>0.32</td>
<td>1</td>
<td>12.29</td>
<td>14.28</td>
<td>2.59</td>
<td>-</td>
<td>-</td>
<td>-0.48</td>
<td>p-value = 0.27</td>
<td></td>
</tr>
</tbody>
</table>
6. Conclusion

As in the other large cities of the world, the regulatory process in the Istanbul taxicab market has dramatically increased medallion prices as well. There are many studies that depict the dramatic increase in medallion prices. However, there is no study that estimates the effect of economic regulation on medallion prices. Developing a model for understanding what happens when the entry in the taxicab market is restricted, this paper estimates the effect of entry restrictions over real medallion prices in the case of Istanbul.

We can make some interesting comments regarding our findings. First, the regulated market structure that is observed in the Istanbul case coincides with both the approaches and findings of theoretical and empirical literature concerning the effects of entry regulation in taxicab markets. The findings show that, when the number of medallions is remained constant, the price of medallions rises, as expected. On the other hand, there is a negative relationship between the number of taxis per thousand people and the price of medallions. We can say that a continuing entry restriction would push medallion prices to higher levels and gives rise to artificial rents and/or the welfare losses from regulation, in parallel of the literature.

Second, in the case of Istanbul, we estimate that a 1% decrease in the number of taxis in the market brings about a 0.71% increase or artificial rent over real medallion prices. This result can be interpreted as a long-run elasticity of medallion prices. Accordingly, real medallion prices are negatively sensitive around 0.71% to a 1% change in the number of taxis. This evidence is compatible with both the expectation of our model and the literature claiming that entry regulation increases medallion prices.

Third, our results also show that entry regulation pressures indirectly on inflation. Entry restriction triggers increase in medallion prices and increase in medallion prices also pressures on inflation. The sensitivity of inflation with respect to changes in medallion prices is 0.32. In other words, a 1% increase in real medallion prices brings about a 0.32% increase in inflation. This finding is not a well-known or estimated result in the literature. This means that this result is a newly contribution to the study of taxicab regulation.

Lastly, our model could be run to other cities, with differing regulatory regimes, or with the deregulated taxicab markets. Moreover, the model could be employed to estimate the effects of structural changes in the regulatory and/or deregulatory processes in the different areas of transportation like airline and railways industries on the market indicators such as price and output.

Appendix A

Fig. A1 illustrates the long-run equilibriums and the constants, which are the average equilibrium levels of medallion prices and inflation, in the three periods. Observe that the shaded areas cover the inter-break periods.

Fig. A1. Long-run equilibriums of medallion prices and inflation in the three periods.

References

Cumming, D., 2009. Why has the price of taxi medallions increased so dramatically?: An analysis of the taxi medallion market. The Park Place Economist 17, 12–17.