METU Studies in Development, 29 (1-2), 2002, 109-122

Modelling private manufacturing investment in Turkey

Pelin Kale Attar
State Planning Organization, Necatibey Cad. No 108, Yücetepe, Ankara Turkey
Adil Temel
State Planning Organization, Necatibey Cad. No 108, Yücetepe, Ankara Turkey

Abstract

This paper presents an empirical model of private manufacturing investment in Turkey based on a neoclassical model of investment that allows for costly adjustment of capital. Before the resultant error correction model is estimated, the long run effects of public investment on private capital formation are investigated using multivariate cointegration techniques. Our empirical results show that in the long run, private manufacturing investment responds positively to an increase in the manufacturing sector's real income and negatively to an increase in public investment or cost of capital. The short run dynamics of private investment captured through the ECM suggest that the current period's public investment has a negative impact on private capital formation, while a positive effect is observed with a lag of one year.

1. Introduction

Recent years have witnessed an increasing interest in the empirical modelling of private investment at the economy-wide or sectoral level in less developed countries. Empirical research on the determinants of private investment in developing economies not only shed light on the determinants of economic growth but also provide invaluable feedback for the design and implementation of stabilization policies, most of which depend on cuts in the spending of governments' public investment programs[1]. These efforts to rationalize public investment programs during fiscal adjustment may have adverse effects on private investment or just the contrary, may create opportunities for private investment depending on

[1] For a survey of literature on determinants of private investment in developing economies, see Chhibber *et al*. (1992), Blejer and Khan (1984), Tun Wai and Wong (1982) Sundararajan and Thakur (1980) and Bilsborrow (1977).

the relative magnitudes of the substitution and complementary effects between public and private capital.

In this study, our purpose is to explore the short run and long run effects of government investment on private manufacturing sector investment in Turkey. We believe that such an empirical study will serve as a good example that can provide feedback in determining the relevance of measures taken during structural adjustment programs. The theoretical framework comes from the neoclassical investment demand function that allows for costly adjustment of capital stock. Private investment is modelled as a function of real income, government investment and costs of capital.

In the search for possible long run relationships between private investment and the explanatory variables, we use multivariate cointegration techniques proposed by Johansen (1988, 1992) and Johansen and Juselius (1990). We explore the short run dynamics through an error correction model (ECM) that allows us to capture the possible lagged response of private investment expected as a result of the existence of adjustment costs and the possible role of uncertainty and irreversibility[2].

The organization of the paper is as follows: In Section 2, we provide an overview of the Turkish economy during the period under study. In Section 3, we present the theoretical framework of our empirical analysis. Section 4 comprises of the description of data used and presentation of empirical results. Finally, in Section 5, we conclude.

2. An overview of the Turkish economy

Basic economic policies of Turkish governments during the 1960s and 1970s were influenced by active government participation in economic activity and import-substituting industrialization strategies. In the aftermath of the 1980 crisis, Turkey changed her overall development strategy and adopted outward-oriented policies with the aim of achieving export-led growth. The new philosophy, which relied heavily on market forces, was supported by the declared intentions of the then authorities which supported maximizing private sector participation in economic activity and the minimization of state interventions and the public share in manufacturing industries.

Several measures were needed to enhance domestic savings and channel these savings into physical investment. Decontrolling prices, restructuring the financial system through the establishment of money and capital markets, adopting a flexible exchange rate regime and liberalising interest rates served these purposes. The new focus of the public investment strategy was on the development of economic and social

[2] See Dixit and Pindyck (1994).

infrastructure[3]. The share of public sector investments in the manufacturing industry declined gradually and the withdrawal process of the public sector from sectors where private sector was willing to operate deepened during the post-1990 period[4]. However, lower levels of public investment in the manufacturing industry were not compensated by private sector investments either[5]; which could be attributed to high levels of resource utilization costs and the existence of idle productive capacity at the beginning of the 1980s.

The effects of macroeconomic policies and reforms of 1980s on the behavior of private investment have been studied by a few researchers. Among them, Celasun and Tansel (1993) estimated several specifications for private investment with a focus on the impact of distributional and financial variables on the saving-investment behavior, in conjunction with the effects of other factors suggested by policy experience and theory. Based on statistical criteria provided by diagnostic tests, they chose a best-performing model among several specifications and obtained a long run relationship between private investment and its determinants[6]. This relation captures the flexible accelerator mechanism (a positive effect of expected sales and a negative effect of the interest rate on private investment) under the positive influence of import availability. They also reported a negative effect for the unexpected component of inflation on private investment.

Conway (1990) explored the relationship between the nominal interest rate, nominal exchange rate, real private sector investments, relative price of capital, real gross domestic product (GDP) and the inflation rate within the framework of a vector autoregressive (VAR) model. He reported that a fall in the rate of inflation and interest rates, and the stability of the first differences of these variables have a positive effect on private sector investments.

More recently Günçavdı, Bleaney and McKay (1998) estimated a private investment function for Turkey to investigate the effects of financial liberalization in the early 1980s. They report that as a consequence of financial liberalization, the short run dynamics of investment were altered and sensitivity to credit availability was reduced.

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3 The share of transport and communication sector in public investments was realised as 37.6% during 1990-1994, approximately fifteen points higher that its average level during 1980-1984.

4 The share of manufacturing industry in public sector's total gross fixed investments decreased from a period average of 19.4% in 1980-1984 to 7.9% in 1985-1989 and to 4.3% in 1990-1994.

5 The share of manufacturing industry in private sector's investments declined to a period average of 26.1% during 1985-1989 and to 24.8% during 1990-1994 from a corresponding level of 32.7% in 1980-1984.

6 The estimated long run relationship is as follows:
$IPF = 0.604\Delta Y_{-1} + 0.516M - 6.739r - 4.138PU$ where IPF is private investment, Y is output, M is import availability, r is the interest rate and PU is unexpected inflation.

However, they find no evidence of increased sensitivity to the cost of capital.

Apart from these studies that pertain to investment behavior in Turkey, there exist other empirical work that handle the issue using a broader set of data, covering other countries as well. For example, Bairam and Ward (1993) modelled the investment expenditures for twenty five OECD countries including Turkey for the period 1950-88 using annual data and maximum likelihood methods. They report a positive effect of the income variable supporting the accelerator principle and no significant effect of government expenditures on investment.

Neither of the studies mentioned above tested the time series data for stationarity. However, using non-stationary data brings about the danger of spurious regression estimates. In this study, before we proceed to the modelling of the private manufacturing investment function, we test for and establish the stationarity of our data series. Orders of integration of all data series are determined through unit root tests and long run relationships are explored using cointegration techniques. Finally, an error correction model is built to investigate the short run dynamics of private manufacturing sector investment.

3. The model

The theoretical background comes from the neoclassical intertemporal model of a profit maximizing firm which leads to the following expression for the equilibrium level of investment (I^*):

$$I^{¿} = F(Y, C, \delta) \tag{1}$$

where Y is the level of output, C is the cost of capital and δ is the depreciation rate of the capital stock. If we allow for adjustment costs that are incurred as a result of unplanned changes in the capital stock and assume the following adjustment cost function suggested by Nickell (1985):

$$E_t\left\{\sum_{s=0}^{\infty}\beta^s\left[\gamma_1\left(I_{t+s}-I^{¿}_{t+s}\right)^2+\Delta I^2_{t+s}-2\gamma_2\Delta I_{t+s}\Delta I^{¿}_{t+s}\right]\right\}$$

(2)

then the firm will solve the above minimization problem for $s \geq 0$.

In Eq. (2), E_t is the expectations operator conditional on the firm's information set at time t, β ($0 \leq \beta \leq 1$) is the subjective discount factor and γ_1, $\gamma_2 \geq 0$ are parameters that determine the relative importance of disequilibrium to adjustment costs.

The forward solution to the first order condition for the minimization of Eq. (2) is given by:

$$\Delta I_t = \gamma_2 \Delta I^{\dot{c}}_{t-1} + (1-\lambda)\left\{\left[\lambda_2 I^{\dot{c}}_{t-1} + (1-\gamma_2)(1-\beta\lambda)\sum_{j=0}^{\infty}(\beta\lambda)^j E\left(I^{\dot{c}}_{t+j}\right)\right] - I_{t-1}\right\} \quad (3)$$

where $\lambda < 1$ is the stable root of the Euler equation obtained from the first order condition.

Following Günçavdı, *et al*. (1998), we assume that the following law of motion holds for $I^{\dot{c}}_{t+j}$, i.e., that expected future levels of investment follow a random walk process with drift:

$$E\left(I^{\dot{c}}_{t+j}\right) = I^{\dot{c}}_t + \mu j \quad (4)$$

Then, substitution of Eq. (4) into Eq. (3) yields the following error-correction model for investment:

$$\Delta I_t = \alpha_0 + \alpha_1 \Delta I^{\dot{c}}_t + \alpha_2\left(I^{\dot{c}}_{t-1} - I_{t-1}\right) \quad (5)$$

where $\alpha_0 = (1-\lambda)(1-\gamma_2)\beta\lambda\mu/(1-\beta\lambda)$, $\alpha_1 = \left[1-(1-\gamma_2)\lambda\right]$ and $\alpha_2 = (1-\lambda)$

Our empirical estimation is based on the reparametrized form of Eq. (5) which is presented below:

$$\Delta I_t = \alpha + \sum_i \beta_i \Delta X_{it} + \theta\left(I_{t-1} - I^{\dot{c}}_{t-1}\right) \quad (6)$$

where ΔX_i are the first differences of the explanatory variables that are postulated to effect private investment and the term in brackets represents deviation of investment from its long run level.

4. Data and empirical results

4.1. Data

We use annual data covering the 1975-1995 period. All data are expressed in 1994 prices and are in logarithms. The definitions and sources of the variables used in modelling private manufacturing investment are presented below:

PRIVI: Private sector's real investment in the manufacturing industry.
Source: State Planning Organization of Turkey.

YMANUF: Manufacturing sector's real income.
Source: State Institute of Statistics of Turkey.

ICOSTS: Relative price of investment goods constructed as the ratio of the investment deflator of the private manufacturing sector to the GDP deflator.
Source: State Planning Organization of Turkey.

GVIINF: Public sector's real investments in infrastructure constructed as the sum of investments in the energy sector and the transportation sector.
Source: State Planning Organization of Turkey

In terms of the effects of the explanatory variables on private investment, we expect a positive relationship between manufacturing sector's real income (*YMANUF*) and private investment (*PRIVI*) if an accelerator mechanism linking income to investment exists.

The variable *ICOSTS,* used as a proxy for the cost of investment, separates the effects of borrowing costs from the cost of investment, which is a more realistic representation of the cost of capital in a developing economy with imperfect capital markets (see Shafik, 1992). The higher this ratio is, the higher the relative price of investment goods; so the sign of its coefficient is expected to be negative.

The impact of *GVIINF,* government investment in infrastructure, on private investment is uncertain. On the one hand, public investment activity may complement private investment and support it. On the other hand, if it substitutes for it, it may dampen private investment. High public sector investment rates may also 'crowd out' private investment when means of financing leads to credit rationing or a heavier tax burden. This empirical question will be addressed in the following sections.

4.2. Stationarity testing

We employed Dickey-Fuller (DF) and Phillips-Perron (PP) unit root tests to test for the orders of integration of our data series. The results presented in Table 1 suggest that the levels of all data series are integrated of order one or I(1). Stationarity is achieved by first differencing.

Table 1
Test Results for Unit Roots

	Stationarity around a non-zero mean		Stationarity around a linear trend	
Variable	DF	P-P	DF	P-P
PRIVI	-0.455	-0.649	-1.104	-0.984
ICOSTS	-1.894	-1.736	-1.754	-1.736
GVIINF	-2.019	-2.095	-0.869	-0.854
YMANUF	-0.036	0.030	-2.030	-2.043
D(PRIVI)	-3.882**	-3.901**		
D(ICOSTS)	-4.040**	-4.024**		
D(GVIINF)	-4.231**	-4.238**		
D(YMANUF)	-4.325**	-4.320**		

Notes: 1 - The superscripts ** and * denote rejection at the 1% and 5% critical values respectively.

2 - $D(X)$ refers to the first difference of variable X; i.e., $D(X)= X-X(-1)$

4.3. Long run analysis - cointegration

Upon finding that all of the data series are I(1), we note that cointegration of *PRIVI* with *YMANUF*, *ICOSTS* and *GVIINF* is a necessary condition for the existence of a long run relationship among them.

Within the framework of Johansen's maximum likelihood procedure, a second-order[7] VAR model for *PRIVI*, *YMANUF*, *ICOSTS*, *GVIINF* is estimated. The results for testing the number of cointegrating vectors reported in Table 2 point to the existence of a unique cointegrating vector. The estimated parameters of the long-run relationship (β) and the adjustment vector (α) which determines the strength of the cointegrating vector are presented in Table 3.

Table 2
Johansen's Test for the Number of Cointegrating Vectors

VAR with 2 lags
Testing the Rank of Π

Maximal Eigenvalue				Trace			
H_0	H_1	Stat.	90%	H_0	H_1	Stat.	90%
r = 0	r ≥ 1	21.52	17.15	r = 0	r = 1	41.11	43.84
r ≤ 1	r ≥ 2	11.50	13.39	r ≤ 1	r = 2	19.59	26.70
r ≤ 2	r ≥ 3	7.99	10.60	r ≤ 2	r = 3	8.08	13.31
r ≤ 3	r ≥ 4	0.09	2.71	r ≤ 3	r = 4	0.09	2.71

Note: r denotes the number of cointegrating vectors.

[7] Before applying Johansen's maximum likelihood procedure to estimate α and β, it is necessary to determine the lag length, k, of the VAR system. The lag length must be chosen such that both the errors are white noise and estimation is possible. Based on the results from the diagnostic tests, we chose $k = 2$.

Table 3
α and β vectors

Variable	β'	α
PRIVI	1.000	-0.443
		(-4.611)
YMANUF	-2.998	-0.107
		(-2.704)
ICOSTS	0.996	-0.021
		(-0.448)
GVIINF	2.655	0.001
		(0.005)

Note: Numbers in parenthesis are the t-values.

From the estimated adjustment vector α, it is observed that the coefficient on the cointegrating vector in the *ICOSTS* and *GVIINF* equations is close to zero and insignificant. To test this finding formally, we perform weak exogeneity tests for each variable; i.e., we test whether the coefficient in the adjustment vector corresponding to each variable is zero. Based on the results of the weak exogeneity tests, reported in Table 4, we cannot reject that *YMANUF*, *ICOSTS* and *GVIINF* are both separately and jointly weakly exogenous. This finding enables us to re-specify the system as a single equation model for *PRIVI* conditioning on other explanatory variables. After imposing the weak exogeneity restrictions on *YMANUF*, *ICOSTS* and *GVIINF*, we re-estimate the model and obtain the long run relationship and the adjustment vector reported in Table 5.

Table 4
Results of the Weak Exogeneity Tests

Null	L-R Test Statistic		Probability value
$\alpha_1=0$	7.35	[$\chi^2(1)$]	0.01
$\alpha_2=0$	3.79	[$\chi^2(1)$]	0.05
$\alpha_3=0$	0.15	[$\chi^2(1)$]	0.69
$\alpha_4=0$	0.00	[$\chi^2(1)$]	1.00
$\alpha_2=\alpha_3=\alpha_4=0$	7.58	[$\chi^2(3)$]	0.06

Table 5
α and β Vectors from the Restricted Model

Variable	β'	α
PRIVI	1.000	-0.266
		(-1.554)
YMANUF	-1.829	-
ICOSTS	2.818	-
GVIINF	1.183	-

The signs of the estimated long run coefficients indicate that an increase in the manufacturing sector's real income leads to an increase in the level of private investment, while an expansion in public sector's investments in infrastructure leads to a decline in private investment. This finding suggests a crowding out effect of government investment on private investment in the Turkish manufacturing industry. However, it does not necessarily imply that the public sector's investment activity is a substitute for that of the private sector when we consider that public sector's borrowing policy in Turkey has been primarily based on domestic debt in the form of issuance of government bonds. This practice might be rendering high interest yielding government bonds more attractive that physical investment and leading to a crowding out effect.

4.4. Short run modelling – The error correction model

In this section, we estimate the error correction model (ECM) for *PRIVI* based on the specification:

$$\Delta PRIVI_t = \alpha + \beta(L)\Delta YMANUF_t + \gamma(L)\Delta ICOSTS_t + \delta(L)GVIINF_t + \theta RES_{t-1} + \varepsilon_t$$

where $\beta(L)$, $\gamma(L)$ and $\delta(L)$ are polynomials in the lag operator and RES_{t-1} is the error correction term reflecting the deviation of private investment from its long run level. More specifically, it corresponds to the one-period lagged values of the residuals obtained from the estimated cointegrating vector.

Following a 'general-to-specific' simplification procedure; we estimate the ECM using the ordinary least squares method and eliminate the negligible and insignificant effects through a sequential reduction process consistent with the approach suggested by Hendry (1995). The final restricted estimates of the ECM are reported in Table 6.

Table 6
Short –Run Model for PRIVI

Dependent Variable: D(*PRIVI*)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.150314	0.020913	-7.187499	0.0000
D(*PRIVI*(-1))	-0.201891	0.092127	-2.191437	0.0489
D(*ICOSTS*)	-1.305242	0.266567	-4.896491	0.0004
D(*GVIINF*)	-0.343106	0.114774	-2.989400	0.0113
D(*GVIINF*(-1))	0.641095	0.103662	6.184461	0.0000
D(*YMANUF*)	2.469375	0.315842	7.818375	0.0000
RES(-1)	-0.366626	0.058089	-6.311491	0.0000
R-squared	0.921422	Mean dependent var		0.017324
Adjusted R-squared	0.882133	S.D. dependent var		0.173354
S.E. of Regression	0.059516	Akaike info criterion		-2.527847
Sum Squared Resid.	0.042505	Schwarz criterion		-2.179895
Log Likelihood	31.01454	F-statistic		23.45244
Durbin-Watson stat	2.634915	Prob(F-statistic)		0.000006

The standard diagnostic tests reported in Table 6 show that the model is statistically well specified. We re-estimate the ECM recursively to check for parameter constancy. Figure 1 is a plot of one step residuals with their corresponding calculated equation standard errors, and the sequences of one step-up, 'N decreasing' and 'N increasing' Chow statistics. There is no significant variation over time in the equation standard errors and the Chow statistics are within their 5% critical values. Recursively estimated coefficients of the model are plotted in Figure 2. They are all within their (+-2) *ex ante* standard errors. These findings jointly and strongly point to the structural stability of the ECM.

The short run ECM model implies that private investment responds positively to increases in the manufacturing income and negatively to an increase in the level of public sector investment activity or costs of investment. The short run dynamics of private investment is affected positively by the one-period lagged level of $\Delta GVIINF$. This suggests that although a crowding out effect of government investment is observed in the current period, government investment has positive spillover effects on private investment in the following period.

The magnitude of the coefficient of the disequilibrium term, *RES*(-1), implies that after a shock is given to the system, it takes approximately three periods, which corresponds to three years in our analysis, for private investment to restore its equilibrium level.

Figure 1
Results of One-Step Residual and Chow Tests

Figure 2
Recursively Estimated Coefficients

4. Conclusion

In this study, we modelled the private sector's manufacturing investment in Turkey for both the long run and the short run. Our model specification, which allows for costly adjustment of capital, facilitates our attempts to understand the dynamic adjustment processes in investment behavior.

Results from the long run analysis, which is based on multivariate cointegration techniques, point to the existence of a unique cointegrating vector among private manufacturing investment, real manufacturing income, cost of capital, and government investment in infrastructure. This long run relationship suggests a positive link between income and private manufacturing investment. The long run effects of public capital formation and investment costs on private manufacturing investment are, on the other hand, found to be detrimental.

The short run dynamics of private manufacturing investment, examined through an error correction model, suggests that the current period's real income and the one-period lagged difference of government investment have positive effects on capital formation in the private manufacturing industry. Current period's government investment and cost of capital, on the other hand, have an adverse effect on private manufacturing investment.

Our results provide evidence of a crowding out effect of government policy in Turkey, although our findings do not necessarily imply that public and private investments are substitutes. Even if they are complementary, the high costs of financing public sector investments in a developing economy like Turkey might reduce the quantity of credit available to the private sector. Furthermore, budget deficits that have reached significant levels especially during the post-1990 period and their sources of finance, which are primarily based on domestic borrowing, might have adverse effects on private investment by rendering the returns from bonds issued by the public sector much more attractive than the returns from physical investment.

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Özet

Türkiye özel imalât sanayi yatırımlarının modellenmesi

Bu çalışmada Türkiye özel imalât sanayi yatırım verileri, sermaye stokunda maliyetli uyum süreci varsayımını göz önünde bulunduran bir neoklasik yatırım modeli çerçevesinde incelenmiştir. Kamu yatırımlarının özel sermaye oluşumu üzerindeki uzun

dönem etkileri çoklu koentegrasyon metodolojisi kullanılarak araştırılmış, kısa dönem etkileri ise bir "hata düzeltme modeli" oluşturularak incelenmiştir. Ampirik bulgulara göre özel imalât sanayi yatırımları uzun dönemde gelir değişkeni ile pozitif; kamu kesimi sabit sermaye yatırımları ve yatırım maliyetini yansıtan değişkenlerle ise negatif ilişkilidir. Modelin kısa dönem dinamiklerinde özel kesim imalât sanayi yatırımları üzerinde kamu yatırım değişkeninin cari döneme ait büyüklüğünün negatif, bir yıl gecikmeli değerinin ise pozitif etkili olduğu gözlenmiştir.