Economic Consequences of the *Intifada*: Investment and Political Instability in Israel

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Abstract

We construct a time-series model of investment in Israel that incorporates both traditional economic factors derived from a theoretical model of a profit-maximising representative firm and indicators of political instability and unrest. This is used to estimate the extent to which the *Intifada* has depressed Israeli investment and the size of the corresponding "peace dividend".

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1. Political Instability, Investment and Growth

The 1990s have seen a boom in research attempting to explain the extent to which differences in economic performance across countries are due to social and political rather than narrowly economic factors. The starting point for much of this research is growth theory, and the methodology applied often involves the modification of traditional economic growth models to include social and political features. Because continuous time-series data on political indicators is often limited, empirical research has focussed on cross-country comparisons, and in particular the panel data sets compiled by the World Bank.

Many of the papers using cross-country panel data to examine hypotheses about convergence in GDP growth rates now include indicators of the quality of each country's society and polity. Among these are the degree of democracy, the degree to which civil and political rights are respected and the incidence of political violence. It is thought that the absence of democracy or civil and political rights, or the presence of political violence, may increase the risks associated with long term investment and so depress factor accumulation. In addition, they may disrupt economic activity or distort factor allocation, reducing factor productivity and hence investment demand. A large number of the papers are surveyed by Alesina and Perotti (1994); recent additions to the literature include Easterly and Levine (1997) and Fedderke and Klitgaard (1998). Whilst different papers find different sociopolitical indicators to be significant in explaining variations across countries, there is a consensus that a substantial fraction of the variation is to be explained by the quality of a country's polity. However, it is often unclear to what extent political factors matter because they affect factor productivity and to what extent they matter because they affect factor accumulation.

For this reason a number of economists have used cross-country data to explore directly the link between the level of investment and the quality of the polity in which it takes place. All authors find some positive relationship, but there is no consensus about the appropriate indicator(s) of polity quality. Alesina and Perotti (1993) explain variations in cross-country investment performance by using a "sociopolitical instability index" constructed by principal components analysis. The important factors in the index are indicators of the absence of democracy and the incidence of political violence. Kormendi and Meguire (1985) and de Haan and Siermann (1996) discover a negative cross-country correlation between the investment-GDP ratio and both the frequency of changes of government and indices of political freedom.

Svensson (1998), drawing on the work of Tornell and Velasco (1992), uses international cross-sectional data to investigate the link between the investment-GDP ratio and various measures of polity quality. He finds that part of the variation in investment performance can be explained by differences in the quality of property rights; no other aspect of the quality of a polity has any significant explanatory power.

An additional issue raised by Collier and Gunning (1999) is that political instability and risk may affect not only aggregate investment but also the composition of investment. In risky environments, the demand for nontraded capital goods (buildings and other construction works) may be particularly low, because these not geographically mobile and cannot be shipped out to another area if there is a major breakdown in civil society. Some traded capital goods (machinery and equipment) are more mobile, and therefore less of a risk. An increase in political instability may therefore reduce construction investment more than machinery and equipment investment.

Whatever the precise nature of the link between polity and investment, this work does not directly address the question of whether an individual country can improve its investment performance by improving the quality of its political system. No-one seriously claims that the causal link between political and economic performance is homogenous throughout the World, so slope coefficients on political variables in cross-country regressions are to be interpreted as the mean effect on economic performance of a certain political characteristic, across countries in the sample.[1] Here the potential value of econometric evidence on individual countries using time-series data - were it available - would be very high.

One country for which time-series data on indicators of political stability do exist, and in which these indicators have exhibited a large degree of variability in recent years, is Israel.[2] In this paper we will construct a macro-econometric model of investment in Israel conditioned on indictors of political stability that correspond to some of those used in cross-sectional analyses. The indicators will nevertheless be motivated by existing empirical political science specific to Israel. The model will distinguish between different types of capital good, in order to address

[1] One serious problem with the panel data regressions is the difficulty in producing an unbiased estimate of this mean value. See Pesaran and Smith (1995).

[2] The term "Israel" will be used to denote the geographical area currently governed from Jerusalem, i.e. the State of Israel within its 1948 borders plus the West Bank, Gaza and the Golan Heights. All place names are purely geographical and have no geopolitical implications.

the point made by Collier and Gunning (1999). The estimated parameters in this model will then be used to calculate the probable impact on Israeli investment of an improvement in political stability, such as might result from a full peace agreement between those political groups that have been in violent conflict. Section 2 discusses relevant details from Israel's recent economic and political history; Section 3 presents the theoretical model, on which is based the econometric model in Section 4. Section 5 concludes.

2. The Economics of the *Intifada*

As a consequence of the 1967 Arab-Israeli war, Israel currently governs territories outside its 1948 borders, including the West Bank, i.e., territory west of the River Jordan but east of the 1948 border, and the area around the city of Gaza. The majority of the population in these areas made up of Palestinian Arabs, many of whom contest the legitimacy of Israeli rule and Jewish settlement of the territories. In December 1987 there was a sudden uprising (*Intifada*) amongst Palestinians in these areas (Peretz, 1990). The uprising consisted of strikes and public demonstrations, which often escalated to the point where protestors were shot dead by Israeli security forces; later there was an increase in the number politically motivated assassinations and attacks on Israeli targets by Palestinian paramilitary groups, particularly *Hamas*. The uprising continued up to September 1993, when the Israeli Government signed an agreement with the Palestine Liberation Organisation (the Oslo Peace Accord). This agreement included PLO recognition of the State of Israel and Israeli recognition of the need for Palestinian self-government in at least part of the West Bank and Gaza areas. The political structures envisaged by the Oslo Peace Accord have not yet been fully implemented, and the political violence and instability have not ceased.

Razin and Sadka (1993, chapter 6) list some of the direct economic consequences of the uprising. Amongst the factors contributing to economic disruption were strikes, boycotts of Israeli goods and tax evasion by Palestinians; and government controls on population movement, curfews and restrictions on the size of bank deposits. The first years of the *Intifada* saw a sharp deterioration in economic performance in the territories. There was estimated to be 10.1% fall in GDP in the West Bank in 1987, a 1.1% fall in 1988 (which would have been much larger, were it not for a bumper olive crop), and 6.2% fall in 1989.

Although accurate figures for the territories are difficult to calculate for the whole of the period, the impact of the *Intifada* on productive investment within the West Bank and Gaza areas may well be relatively small. Economic growth in the territories the years up to 1987 came though an expansion of trade and services, not through industrialisation (Razin and Sadka, 1993, p. 87). Most investment in the area was in the form of residential construction associated with the growth of Jewish settlements. However, the *Intifada* represented an increase in political instability for Israel as a whole that may well have depressed investment demand. The risk to investors might be manifested through a number of channels:

1. The possibility of injury to person or property in paramilitary attacks;
2. The possibility of the uprising spreading to Arab Israelis,[3] who became much more politicised in the 1980s (Mayer, 1988; Rouhana, 1989, 1991);
3. For Arab investors, the possibility of the loss of property rights as a result of Israeli security measures

In the next section, we will refer to existing studies on the perception of political uncertainty in Israel in order to motivate the calculation of time-varying quantitative measures of risk. These measures will be used in a model of investment for the whole of Israel, in order to estimate the sensitivity of aggregate investment to changes in the degree of perceived political instability over time. Estimation of the impact of political instability will be nested in an economic model of aggregate investment.

3. An Integrative Model of Investment

In this section we describe the model of investment that we will use to explore the potential links between political instability and investment performance. Section 4 will present the results of estimating this model using the Israeli quarterly data for the period 1987-98.

In Appendix 1 we derive a theoretical economic model, based on the profit-maximising behaviour of a representative firm, which relates gross investment in (i) non-residential construction, B, and (ii) machinery and equipment, M, to economic conditions. The form of the relationship is:

[3] The term "Arab Israelis" refers to those Arabs with Israeli nationality and right of abode in Israel proper.

$$\ln(I^i)_t = b^i_0 + b^i_1 \cdot \ln(C')_t + b^i_2 \cdot \Delta\ln(C')_t + b^i_3 \cdot \ln(P^B)_t + b^i_4 \cdot \Delta\ln(P^B)_t \tag{1}$$
$$+ b^i_5 \cdot \ln(P^M)_t + b^i_6 \cdot \Delta\ln(P^M)_t + b^i_7 \cdot \ln(W)_t + b^i_8 \cdot \Delta\ln(W)_t + b^i_9 \cdot \ln(Y)_t + b^i_{10} \cdot \Delta\ln(Y)_t$$
$$+ \Sigma_\tau\, g^i_\tau \cdot \ln(I^B)_{t-\tau} + \Sigma_\tau\, h^i_\tau \cdot \ln(I^M)_{t-\tau} + u^i_t$$
$$i = B,M;\ b^i_1, b^i_3, b^i_5, b^i_7 < 0 < b^i_9$$

where I^i_t is gross investment in each type of capital in period t, C'_t the real interest rate (adjusted for capital depreciation), P^i_t the real purchase price of capital goods of type i, W_t the real wage rate, Y_t the output level of the average firm and u^i_t an i.i.d. residual. The intercept b^i_0 may have a seasonal component. In the long run, investment will depend negatively on costs and positively on aggregate output; in the short run, lower past investment in one type of capital will tend to depress investment in the other type, *ceteris paribus* (if you don't own a factory right now, there's no point in buying machines to put in it until you do). The functional form in equation (1) is based on a number of assumptions, outlined in Appendix 1, which might be invalid; so it will be important in any econometric analysis based on equation (1) to test the robustness of the equation used.

This model might be overly restrictive because it does not allow for political factors to affect investment decisions. As outlined in Section 1, increases in either political violence and unrest, or in uncertainty surrounding the future nature of the polity, could reduce investment because they represent an increase in risk against which it is impossible to hedge fully. (As noted in Section 1, these effects may be more marked with respect to construction than with respect to machinery and equipment investment, if the latter is more geographically or sectorally mobile). Moreover, the economic disruption associated with violence and unrest could directly increase firms' costs.[4]

A realistic model of investment in Israel must allow for the potential impact of political conditions in some way. The simplest approach is to use a dummy variable in a time-series regression for the variable of interest. Earlier papers on the economic impact of the *Intifada* (for

[4] Increased uncertainty may also induce hysteresis in an individual firm's investment decisions (Dixit and Pindyck, 1994), with asymmetries in the response of investment to positive and negative shocks. However, as shown by Caballero (1993), these effects are unlikely to generate asymmetries at the aggregate level. In aggregate there may be "excess" smoothness in the response of investment demand to changes in returns, which will be manifested as a higher value of the adjustment cost parameters ϕ and ψ in the model in Appendix 1 and so higher values of $\Sigma_\tau\, g^i_\tau$ and $\Sigma_\tau\, h^i_\tau$ in equation 1. Since we do not try to separate hysteresis from adjustment cost effects, we may be understating the effect of uncertainty on investment.

example Fishelson, 1993) have estimated regression equations beginning before the start of the unrest and ending afterwards, interpreting the coefficient on a dummy variable for the period of unrest as the net economic impact of the uprising. One drawback of this approach is that a single dummy variable is difficult to interpret unambiguously: the *Intifada* started not long after the end of the Israeli hyperinflation period, and a single dummy might conflate the effects of increasing political instability with decreasing macroeconomic instability.

More recently there have been survey-based studies on the factors associated with the subjective perceptions of insecurity amongst Arabs and Jews in Israel. Rouhana and Fiske (1995) use factor analysis to explore the characteristics of Israeli society and politics that evoke a sense of threat in survey respondents. There are 22 characteristics in their questionnaire; the ones evoking the greatest sense of threat in Jewish respondents are:

1. "Attacks and acts of sabotage";
2. "Arabs in Israel join the uprising";
3. "The uprising in the territories".

The ones evoking the greatest sense of threat in Arab respondents are:

4. "Expropriation of Arab land";
5. "Discussions about expulsion of Arabs";
6. "Rise in strength of the right wing / Jewish religious movement".

If the intensity of these characteristics increases (for example, if the number of attacks increases or more Arab land is expropriated) then perceptions of insecurity amongst Jews and Arabs are likely to become more intense. One consequence of this might be a reduction in investment by the Jewish or Arab communities. Moreover, it is possible to construct time series relating to the intensity of these characteristics.

With regard to characteristics 1-3, we can refer to monthly figures for the number of Israelis killed in politically motivated attacks, which are now in the public domain (for example IRIS, 1999), as are annual figures on total deaths including both Israelis and Palestinians (for example B'Tselem, 1999). The monthly data on Israeli deaths can be summed to create a quarterly series that can be used in conjunction with the quarterly macroeconomic data; and an approximate quarterly time series for total deaths can be interpolated from the annual data, for example by the method of Lisman and Sandee (1964).[5] We would expect investment to be negatively correlated with the fatality statistics, either because of the resulting increase in the perceived degree of security by investors or because they are associated with unrest that directly disrupts economic activity. The degree of perceived insecurity may depend on either the number of Jewish deaths, or the total number of deaths, or both figures. Jewish deaths represent a direct threat; the number Palestinian deaths is an indicator of the intensity of the uprising. The number of Israeli deaths (in thousands per quarter) will be denoted $ISRK_t$; the total number of deaths (in thousands per quarter) will be denoted $ALLK_t$. Figure 1 illustrates the fatality statistics. Total fatalities peak at 336 in 1989 and again at 242 in 1993 (the second peak is related to an increase in the number of attacks by Hamas after the signing of the Oslo Peace Accord); Israeli fatalities peak at 87 in 1996.

With respect to characteristic 4, the Israeli Central Bureau of Statistics publishes quarterly data on the number of buildings completed in Jewish settlements in the West Bank and Gaza areas.[6] Not all building in the West Bank and Gaza areas is on expropriated land; but it might be the case that Arabs perceive the expansion of the West Bank and Gaza settlements to be at the expense of Arab property rights, in which case an increase in the rate of expansion will be linked to an intensification of the perceptions of insecurity associated with characteristic 4, and so to lower investment. The rate of growth of the number of buildings completed in Jewish settlements in the West Bank and Gaza areas will be denoted $\Delta\ln(CWBG)_t$. In the regression analysis to follow we will use lags of this variable, because we cannot assume that it is independent of total investment. Figure 2 illustrates the CWBG series. The house building figure peaks at 7,370 per quarter in 1993 (coinciding with the second peak in the total fatality statistics), then levels of at around 400 per quarter in the late 1990s.

Characteristics 5-6 relate to the strength of (extreme) right-wing political opinion. The only direct measure of the strength of political opinion is in election results; so it is difficult to

[5] Characteristic 2 suggests that the location of *Intifada*-related attacks might matter. Data on the location of attacks are available (B'Tselem, 1999); but such figures were never significant when included in regression equations of the type presented in Section 3.

[6] Figures before 1990 are reported only annually; the quarterly figures for 1988-9 are interpolations.

construct a quantification of these characteristics with very much time series variation. For this reason we will use dummy variables: one for quarters following the Labour Party victory in the summer of 1992 (denoted LABIN), and one following the Labour Party defeat in the summer of 1996 (denoted LABOUT). We anticipate investment to be higher under a Labour administration because Labour politicians are perceived to be less tolerant of extreme right-wing views than are politicians of the Likud coalition. (However, there are more prosaic explanations for a positive Labour Party dummy, since the different political parties have different economic policy programmes.)

In addition to these factors there is one other event which might be associated with changes in investment demand: the signing of the Oslo Peace Accord between the Israeli Government and the PLO in September 1993. This accord provided for the recognition of the State of Israel by the PLO and for the creation of a Palestinian state in part of the West Bank / Gaza. Al-Haj *et al.* (1993) present survey results outlining Jewish and Arab attitudes to the creation of a Palestinian state. 69% of the Jewish sample responded that the existence of such a state would reduce their own personal safety, and 18% responded that it would increase their personal safety. By contrast, the corresponding figures for the Arab sample are 6% and 76%. Given that the majority of the Israeli population is Jewish, we might expect the accord to have resulted in lower investment, if these figures are representative of investors in each community. But besides being a cause of changes in the level of uncertainty, the Accord may also be a consequence of increased uncertainty. Astorino-Courtois (1995) argues that Palestinian and Israeli peace negotiators are more inclined to moderate behaviour and co-operation in decision environments characterised by uncertainty. Here "uncertainty" refers to the degree of complexity in analysis of foreign policy issues, of which one major factor is the degree of transparency / ambiguity in leaders' public speeches and behaviour; but this kind of uncertainty may also affect investors' perceptions of risk. So a period of high co-operation (such as at Oslo) may reflect a high level of uncertainty which also happens to discourage investment. We will include in our model a dummy variable for periods following the Accord (denoted OSLO).

In the next section we will estimate investment equations which allow for the political factors discussed above, using a modification of equation (1):

$$\ln(I^i)_t = b^i_0 + b^i_1\cdot\ln(C')_t + b^i_2\cdot\Delta\ln(C')_t + b^i_3\cdot\ln(P^B)_t + b^i_4\cdot\Delta\ln(P^B)_t \qquad (2)$$

$$+ b^i_5 \cdot \ln(P^M)_t + b^i_6 \cdot \Delta\ln(P^M)_t + b^i_7 \cdot \ln(W)_t + b^i_8 \cdot \Delta\ln(W)_t + b^i_9 \cdot \ln(Y)_t + b^i_{10} \cdot \Delta\ln(Y)_t$$
$$+ \Sigma_\tau\, g^i_\tau \cdot \ln(I^B)_{t-\tau} + \Sigma_\tau\, h^i_\tau \cdot \ln(I^M)_{t-\tau} + f^i_1 \cdot ISRK_t + f^i_2 \cdot ALLK_t + f^i_3 \cdot \Delta\ln(CWBG)_{t-4}$$
$$+ f^i_4 \cdot LABIN_t + f^i_5 \cdot OSLO_t + f^i_6 \cdot LABOUT_t + u^i_t$$

This will allow us to evaluate the extent to which political instability and unrest have depressed investment in the Israeli economy, and to determine whether these factors have influenced construction more than machinery and equipment investment.

4. Modelling Investment in Israel

In this section we present the estimation and interpretation of the investment model represented by equation (2) above. The sources for the political time series have already been discussed; the economic data are taken from the Israeli Central Bureau of Statistics' *Monthly Bulletin of Statistics* (much of which is available via the CBS website http://www.cbs.gov.il); Figure 3 depicts the $\ln(I^B)$ and $\ln(I^M)$ series; Appendix 2 details the construction of the variables in the econometric model.

3.1 Cointegrating Relationships

Table 1 presents descriptive statistics for the variables of interest. The first part of the table lists Augmented Dickey-Fuller test statistics (Dickey and Fuller, 1979) for all of the variables: it is possible to reject the null that the series are I(1) only in the case of $\ln(P^B)$, $\ln(P^M)$, $\Delta\ln(CWBG)$, ISRK and ALLK. For the other variables ($\ln(I^B)$, $\ln(I^M)$, $\ln(Y)$, $\ln(W)$ and $\ln(C')$) this null cannot be rejected, although the null that they are I(2) can. So it is appropriate to estimate the model by first looking for a cointegrating relationship between $\ln(I^i)$, $\ln(Y)$, $\ln(W)$ and $\ln(C')$:

$$\overline{\ln(I^i)} = \overline{\mu}^i_1 \cdot \ln(Y) + \overline{\mu}^i_2 \cdot \ln(W) + \overline{\mu}^i_3 \cdot \ln(C') \qquad (3)$$

and then constructing a regression equation of the form:

Figure 1: Annual Deaths in the *Intifada*

Figure 2: Logarithm of Number of Buildings Completed per Quarter in Jewish Settlements in the West Bank and Gaza Areas

Figure 3: Logarithms of Real Investment in Machinery and Equipment (I^M) and Non-Residential Construction (I^B), Thousands of 1998 Shekels

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$$\Delta\ln(I^i)_t = d^i_0 + d^i_1\cdot\Delta\ln(C')_t + d^i_2\cdot\Delta\ln(P^B)_t + d^i_3\cdot\Delta\ln(P^M)_t + d^i_4\cdot\ln(P^B)_t \quad (4)$$
$$+ d^i_5\cdot\ln(P^M)_t + d^i_6\cdot\Delta\ln(W)_t + d^i_7\cdot\Delta\ln(Y)_t + d^i_8\cdot\varepsilon^B_{t-1} + d^i_9\cdot\varepsilon^M_{t-1} + d^i_{10}\cdot\Delta\ln(CWBG)_{t-4}$$
$$+ d^i_{11}\cdot ISRK_t + d^i_{12}\cdot ALLK_t + d^i_{13}\cdot LABIN_t + d^i_{14}\cdot OSLO_t + d^i_{15}\cdot LABOUT_t$$
$$+ \Sigma_\tau\, s^i_\tau\cdot\Delta\ln(I^B)_{t-\tau} + \Sigma_\tau\, v^i_\tau\cdot\Delta\ln(I^M)_{t-\tau} + u^i_t$$

where ε^i_t is the residual from the cointegrating vector for $\ln(I^i)$:

$$\varepsilon^i_t = \ln(I^i)_t - \mu^i_1\cdot\ln(Y)_t - \mu^i_2\cdot\ln(W)_t - \mu^i_3\cdot\ln(C')_t \quad (5)$$

Equation (3) is isomorphic with equation (2). We anticipate that for the $\Delta\ln(I^B)_t$ equation, $1 > d^i_9 > 0 > d^i_8 > -1$; and for the $\Delta\ln(I^M)_t$ equation, $1 > d^i_8 > 0 > d^i_9 > -1$, ensuring that the system is stable. The variables ε^B_t and ε^M_t are estimated as follows. Estimation results are summarised in

Table 2.

(i) ε^B_t The two possible ways of testing for cointegration are the methods outlined by Johansen (1988) and by Engle and Granger (1987). Neither method is more powerful than the other in all small samples (Reimers, 1991); but one disadvantage of the Engle-Granger method is that it allows for the existence of no more than one cointegrating vector between the variables of interest. We will employ both methods and then compare the results. Table 2 shows that these are very similar.[7] The Engle-Granger method is applied by calculating an Augmented Dickey-Fuller test statistic for the variable ε^B_t, where ε^B_t is calculated as

$$\varepsilon^B_t = \ln(I^B)_t - [(\Sigma_\tau\, b_\tau)\cdot\ln(Y)_t + (\Sigma_\tau\, c_\tau)\cdot\ln(W)_t]/[1 - \Sigma_\tau\, a_\tau] \qquad (6)$$

The parameters a_τ, b_τ and c_τ are estimated from a dynamic regression of $\ln(I^B)$ on $\ln(Y)$ and $\ln(W)$:

$$\ln(I^B)_t = \Sigma_\tau\, a_\tau\cdot\ln(I^B)_{t-\tau} + \Sigma_\tau\, b_\tau\cdot\ln(Y)_{t-\tau} + \Sigma_\tau\, c_\tau\cdot\ln(W)_{t-\tau} + \text{seasonals} + \nu^B_t \qquad (7)$$

where ν^B_t is an i.i.d. residual.[8] The variable ln(C') is omitted from the regression for reasons discussed below. The null of no cointegration, i.e., that ε^B_t is I(1), can be rejected at the 5% level, as can the same null using the Johansen method, which constructs the μ_i from estimates of a VAR of the I(1) variables. (Moreover, the null that there is no more than one cointegrating vector cannot be rejected using the Johansen method.) The estimates of μ_i derived from each method are very similar: 2.697 and -2.258 for the Engle-Granger method in comparison with 2.751 and -2.476 for the Johansen method. These figures imply a positive long run relationship between construction investment and aggregate output, and a negative relationship between construction investment and the real wage rate. We therefore conclude that $\ln(I^B)$ is cointegrated with ln(Y) and ln(W); the regressions below construct ε^B_t on the basis of the Johansen estimates

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[7] With a large enough sample, the appropriate approach would be to use the Johansen method to search for two cointegrating vectors amongst $\ln(I^B)$, $\ln(I^M)$, ln(Y), ln(W) and ln(C'). With our small sample the power of tests for cointegration amongst five variables is likely to be very low indeed; so it is not surprising that we were unable to identify any cointegrating vectors by taking this approach.

[8] The lag order used is six. The original Engle-Granger method is based on a static regression, but in small samples omission of the dynamics is likely to increase the biases in the estimates of μ_i (Banerjee *et al.*, 1993).

of the long run, but it makes very little difference if the Engle-Granger estimates are used instead.

If the interest rate variable ln(C') is added to the vector of I(1) variables then its coefficient in the cointegrating vector is very small, and the null that it is equal to zero cannot be rejected; so we do not include a ln(C') term in our estimate of ε^B_t. The insignificance of interest rates is a frequent feature of investment regressions in LDCs, and may reflect capital market imperfections (Rama, 1993).

(ii) ε^M_t The results for machinery and equipment investment are more ambiguous. ln(C') is again unimportant, but now it is possible to reject the null of no cointegration between $\ln(I^M)$, ln(Y) and ln(W) only with the Engle-Granger method, and not with the Johansen method. In the absence of any finite sample results demonstrating that one method is more powerful than the other, it is not possible to adjudicate between the two on purely statistical grounds. However, eyeballing the ε^M_t series generated by the Engle-Granger method (Figure 4) suggests that there is a stationary linear combination of the three variables. We will use this series as an explanatory variable in the $\Delta\ln(I^M)$ regressions; the coefficients on ln(Y) and ln(W) implicit in ε^M_t are 2.509 and -1.408, which are again consistent with the theoretical model.

3.2 The Investment Equations

Appendix 3 contains the parameter estimates, standard errors and descriptive statistics for OLS estimates of equation (4) for investment in the two types of capital; a lag order of four on the investment variables is required to ensure that the regression residuals are not autocorrelated. The sample period is 1988(2)-1998(3). Because it is not possible to assume that the economic variables on the RHS of equation (4) are weakly exogenous to investment, these variables are entered in the regression equation with a one-period lag. The very low t-ratios on some of the explanatory variables suggest that the regressions are over-parameterised, so Table 3 in the main text reports regressions in which some explanatory variables have been omitted so as to minimise the Schwartz Bayesian Criterion (this model selection also happens to minimise the Hannan-Quinn Criterion and Akaike Information Criterion). Since different variables are omitted from the two regression equations, and u^B_t

Table 1: Descriptive Statistics

(i) Stationarity Test Statistics

t_{ADF} represents the Augmented Dickey-Fuller test stastistic. Values significant at the 5% level are shown in bold; Banerjee et al. (1993) provide critical values for the test. The other columns indicate the lag length and the presence of deterministic components in the ADF regression equation. The sample is 1987(1)-1998(3) less lags.

variable	t_{ADF}	max. lag	trend	seasonals
ln(IB)	-1.69	4	-	x
Δln(IB)	**-7.32**	3	-	x
ln(IM)	-1.75	4	x	-
Δln(IM)	**-10.65**	0	-	x
ln(Y)	-2.69	0	x	x
Δln(Y)	**-9.11**	0	-	x
ln(W)	-1.31	1	-	x
Δln(W)	**-5.82**	0	-	x
ln(C')	-2.07	5	x	x
Δln(C')	**-4.07**	2	-	x
ln(PB)	**-3.21**	0	x	x
ln(PM)	**-3.89**	0	x	x
Δln(CWBG)	**-8.12**	0	-	-
ISRK	**-6.63**	0	-	-
ALLK	**-4.77**	3	x	-

(ii) Sample Moments: 1988(1)-1998(3)

variable	mean	std. dev.
$\Delta\ln(I^B)$	0.02262	0.17200
$\Delta\ln(I^M)$	0.01929	0.09579
Δln(Y)	0.01094	0.02420
Δln(W)	0.00091	0.01909
Δln(C')	0.00137	0.03722
$\ln(P^B)$	0.17610	0.07951
$\ln(P^M)$	0.22200	0.15530
Δln(CWBG)	0.03071	0.41500
ISRK (000)	0.01074	0.01178
ALLK (000)	0.04247	0.02466

Table 2: Cointegration Statistics

ln(IB): 1987(1) - 1998(4)

(i) Engle-Granger Method

Estimated cointegrating vector (standard errors in parenthesis):

$$\ln(IB) = \underset{(0.064)}{2.697}*\ln(Y) - \underset{(0.398)}{2.258}*\ln(W) + \varepsilon$$

ADF t-ratio on ε_t = -4.362

(ii) Johansen method

Degrees of Freedom Corrected Johansen Rank Test Statistics
Correction based on Reimer (1991); 95% confidence interval shown

rank (p)	λ-max	95%	trace	95%
p = 0	**30.01**	21.0	**34.99**	29.7
p ≤ 1	2.79	14.1	4.98	15.4
p ≤ 2	2.19	3.8	2.19	3.8

First cointegrating relation:

$$\ln(IB) = 2.751*\ln(Y) - 2.476*\ln(W)$$

ln(IM): 1987(1) - 1998(4)

(i) Engle-Granger Method

Estimated cointegrating vector (standard errors in parenthesis):

$$\ln(IM) = \underset{(0.049)}{2.059}*\ln(Y) - \underset{(0.318)}{1.408}*\ln(W) + \varepsilon$$

ADF t-ratio on ε_t = -6.021

(ii) Johansen method

Degrees of Freedom Corrected Johansen Rank Test Statistics
Correction based on Reimer (1991); 95% confidence interval shown

rank (p)	λ-max	95%	trace	95%
p = 0	12.24	21.0	21.45	29.7
p ≤ 1	8.60	14.1	9.21	15.4
p ≤ 2	0.61	3.8	0.61	3.8

and u^M_t are correlated, the Maximum Likelihood estimates reported are different from OLS estimates. Appendix 3 reports SUR estimates of the two equations: the SUR coefficients are very similar to the ML ones. There is no significant autocorrelation or ARCH in u^B_t and u^M_t. There is some heteroskedasticity in the parameter estimates, so Table 3 reports standard errors corrected by the method of White (1980) ("w.c.s.e.") alongside uncorrected ones.

As a check on robustness, the model was estimated recursively, beginning with a sample of 1988(2)-1994(3) and then extending the sample up to 1998(3). The one-step forecast errors for the two equations are plotted in Figure 5; none of the errors is significantly different from zero. Figure 6 shows one-step and break-point Chow Test statistics for the system; never are the statistics significant at the 10% level.

Because the equations are estimated in error-correction format, the dynamic interaction of I^B and I^M is not immediately transparent in Table 3. Table 4 lists the values of the coefficients on lags of $\ln(I^B)$ and $\ln(I^M)$ when the Table 3 equations have been rearranged so that the investment variables appear throughout in (log) levels. Table 4 indicates that the current level of investment in non-residential construction depends positively on its level and rate of growth this time last year; investment over the past three quarters appears not to matter. This suggests that the dynamics of construction investment is dominated by a seasonal pattern. Correspondingly, construction investment in the steady state has a seasonal pattern as indicated by the seasonal intercept dummies in Table 3, investment in the last quarter of the year being 13% lower than investment in the first, *ceteris paribus*. Moreover, a 1% increase in machinery and equipment investment will lead to a rise in construction investment of a little over 0.5%, the effect having a six-month lag. The dynamics of the machinery and equipment investment equation are rather different, with quite small coefficients on lags of the dependent variable: there is much less smoothing here, suggesting lower adjustment costs.[9] Nevertheless, an increase in construction investment has a positive impact on machinery and equipment investment: a 1% increase in the former stimulates the latter by around 0.3% over the subsequent year.

Implicit in the ε^B_t variable is a positive long run relationship between construction investment and aggregate output, and a negative long run relationship between construction

[9] Less smoothing is also consistent with less hysteresis in investment in machinery and equipment because of lower risk.

Table 3: The Restricted Investment Model, FIML Estimates

$\Delta\ln(IB)$

variable	coeff.	std. err.	t ratio	prob.	w.c.s.e.
$\Delta\ln(IB)_{-1}$	-0.67411	0.17742	-3.799	0.0009	0.18471
$\Delta\ln(IB)_{-2}$	-0.63164	0.16060	-3.933	0.0006	0.15422
$\Delta\ln(IB)_{-3}$	-0.57784	0.14778	-3.910	0.0007	0.13309
$\Delta\ln(IB)_{-4}$	0.22850	0.11967	1.909	0.0682	0.11931
$\Delta\ln(IM)_{-1}$	-0.51120	0.17430	-2.933	0.0073	0.17241
$ecmM_{-1}$	0.53444	0.27373	1.952	0.0626	0.29054
$ecmB_{-1}$	-0.41828	0.16952	-2.467	0.0211	0.17978
$\Delta\ln(Y)_{-1}$	0.76884	0.55875	1.376	0.1815	0.67798
$\Delta\ln(C')_{-1}$	-0.73702	0.31535	-2.337	0.0281	0.33792
$\ln(PM)_{-1}$	-0.52620	0.22217	-2.369	0.0263	0.18074
$\Delta\ln(PB)_{-1}$	-0.87350	0.43768	-1.996	0.0574	0.34491
$\Delta\ln(CWBG)_{-4}$	-0.14938	0.03581	-4.172	0.0003	0.03745
ISRK	-2.50740	0.93524	-2.681	0.0131	0.82912
LABIN	0.11087	0.04027	2.753	0.0111	0.04152
OSLO	-0.24032	0.04631	-5.190	0.0000	0.05228
LABOUT	-0.15359	0.04761	-3.226	0.0036	0.04224
Constant	-1.01450	4.29560	-0.236	0.8153	5.90940
Seasonal Dummy 1	-0.02400	0.05861	-0.409	0.6858	0.04809
Seasonal Dummy 2	-0.09558	0.07044	-1.357	0.1874	0.06173
Seasonal Dummy 3	-0.12612	0.05038	-2.503	0.0195	0.04521

$\sigma = 0.05340$

$\Delta\ln(IM)$

variable	coeff.	std. err.	t ratio	prob.	w.c.s.e.
$\Delta\ln(IB)_{-1}$	-0.34182	0.15458	-2.211	0.0368	0.17047
$\Delta\ln(IB)_{-2}$	-0.22686	0.11704	-1.938	0.0644	0.13937
$\Delta\ln(IM)_{-1}$	0.01476	0.23616	0.063	0.9507	0.24253
$\Delta\ln(IM)_{-2}$	0.18046	0.20149	0.896	0.3794	0.17185
$\Delta\ln(IM)_{-3}$	0.25672	0.15810	1.624	0.1175	0.17034
$\Delta\ln(IM)_{-4}$	0.26560	0.15119	1.757	0.0917	0.18897
$ecmM_{-1}$	-0.94174	0.32915	-2.861	0.0086	0.30569
$ecmB_{-1}$	0.30296	0.17573	1.724	0.0976	0.20607
$\Delta\ln(W)_{-1}$	-1.56340	0.70916	-2.205	0.0373	0.48491
$\Delta\ln(CWBG)_{-4}$	-0.06382	0.03577	-1.784	0.0871	0.02828
ALLK	-1.49100	0.57724	-2.583	0.0163	0.61655
OSLO	-0.06523	0.02813	-2.319	0.0293	0.03272
Constant	-6.81050	4.44280	-1.533	0.1384	3.99350
Seasonal Dummy 1	0.05084	0.03872	1.313	0.2016	0.03252
Seasonal Dummy 2	-0.03517	0.05369	-0.655	0.5187	0.04943
Seasonal Dummy 3	-0.11192	0.04741	-2.361	0.0267	0.04993

$\sigma = 0.06190$

Restricted System Statistics

joint restrictions test: $\chi^2(26) = 23.383$ [0.6112] cross-equation residual correlation = 0.33536

$\ln(L) = 265.92$ $\ln|\Omega| = -12.663$ SBC = -9.459 HQC = -10.403 AIC = -10.949

system error normality: $\chi^2(4) = 4.2058$ [0.3789]

system error autocorrelation (order 1): $F(4,42) = 0.9076$ [0.4683]

system error autocorrelation (order 4): $F(16,30) = 1.7390$ [0.0930]

$\Delta\ln(IB)$ equation ARCH (order 1): $F(1,9) = 0.25669$ [0.6246]

$\Delta\ln(IM)$ equation ARCH (order 1): $F(1,9) = 0.00470$ [0.9468]

$\Delta\ln(IB)$ equation ARCH (order 4): $F(4,3) = 0.05416$ [0.9917]

$\Delta\ln(IM)$ equation ARCH (order 4): $F(4,3) = 0.04422$ [0.9943]

Table 4: Investment Dynamics Implicit in the The ML Estimates

Coefficients significantly different from zero at the 10% level are shown in bold.

variable	$\ln(I^B)$ equation coeff.	$\ln(I^M)$ equation coeff.
$\ln(I^B)_{-1}$	-0.09	-0.04
$\ln(I^B)_{-2}$	0.04	0.09
$\ln(I^B)_{-3}$	0.05	**0.23**
$\ln(I^B)_{-4}$	**0.81**	0.00
$\ln(I^B)_{-5}$	**-0.23**	0.00
$\ln(I^M)_{-1}$	0.02	0.07
$\ln(I^M)_{-2}$	**0.51**	**0.17**
$\ln(I^M)_{-3}$	0.00	0.08
$\ln(I^M)_{-4}$	0.00	0.01
$\ln(I^M)_{-5}$	0.00	**-0.27**

Table 5: Weak Exogeneity Tests for ALLK and ISRK

The statistics indicate the significance of each residual in regressions for ALLK and ISRK respectively, the set of exogenous regressors being determined by the AIC; lags of the dependent variable up to order 5 are used as instruments.

residual	ALLK	ISRK
$\Delta\ln(IB)$	$F(1,19) = 2.08$ [0.17]	$F(1,25) = 0.01$ [0.91]
$\Delta\ln(IM)$	$F(1,19) = 0.00$ [0.99]	$F(1,25) = 0.00$ [0.98]
joint	$F(2,19) = 1.15$ [0.34]	$F(2,25) = 0.01$ [0.99]

Figure 4: The Error-Correction Terms ε^i_t for $\ln(I^B)$ and $\ln(I^M)$

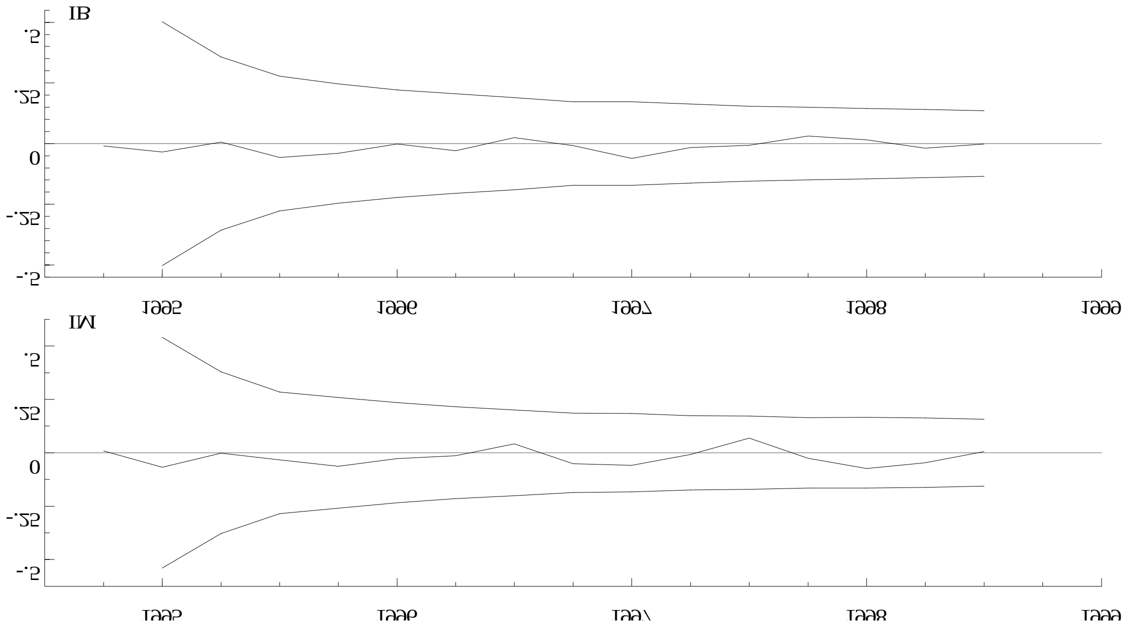

Figure 5: One-Step Forecast Residuals ± 2 Standard Errors

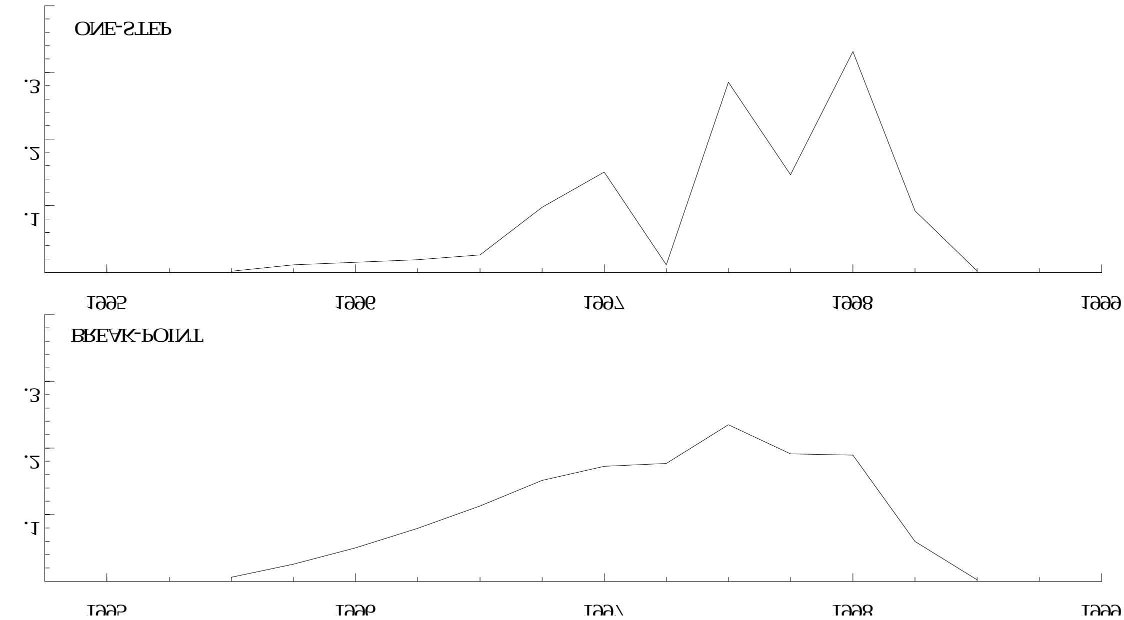

Figure 6: Recursive One-Step and Break-Point Chow Tests for the System as a Fraction of their 10% Critical Value

investment and the real wage. Table 3 indicates that in addition there are temporary effects on construction investment of changes in aggregate output ($\Delta\ln(Y)$), the interest rate term ($\ln(C')$) and the price of construction investment ($\Delta\ln(P^B)$). The estimated impact elasticities are, respectively, 0.77, -0.74 and -0.87. The only cost term besides the wage rate with a significant long run effect is the price of machinery and equipment ($\ln(P^M)$). The impact elasticity associated with this variable is -0.53; the dynamics of the construction investment equation imply that the long run elasticity is -1.26. In the machinery and equipment investment equation, the only significant cost term in addition to those implicit in $\varepsilon^M{}_t$ is a negative coefficient on the rate of growth of real wages; the estimated impact elasticity is equal to -1.56.

The overall picture from Tables 2-3 is that the economic variables dominating the evolution of investment in Israel are aggregate output and the real wage rate. Changes in capital costs, captured by the real interest rate and the purchase price of capital goods, have some temporary impact on investment but (with the exception of the price of machinery and equipment) no significant permanent impact. This result is in line with other work on LDC investment (Rama, 1993). The results here suggest that to the extent that investors' decisions are based on economic factors, they are largely influenced by aggregate demand and labour costs.

Perhaps the most interesting feature of the regression results is the role played by measures of political instability. Both the number of Israelis killed and the rate of growth of Jewish settlements in the West Bank and Gaza areas have a significantly negative impact on investment in non-residential construction. Manufacturing and equipment investment is significantly lower when the total number of deaths and rate of growth of the settlements increase. Why the two types of investment should appear to be sensitive to different fatality statistics is a puzzle; but both types of investment are substantially lower when the indicators of political instability are higher.

Since the explanatory variables have not been normalised, and all have different sample variances, and since the two investment equations have different dynamics, the estimated coefficients on the political instability measures are not in themselves very meaningful. For example, it is not possible to say just from the coefficients which type of investment is the more sensitive to political instability overall. One way of measuring the relative sensitivity of the two types of investment to the three political instability variables is to calculate the percentage reduction in investment in each type of capital in the steady-state that would result from an increase in the instability measure by one sample standard deviation, *ceteris paribus*.[10] Using the ML estimates, these figures are:

	ISRK	ALLK	Δln(CWBG)
$\ln(I^B)$	7.05	——	14.82
$\ln(I^M)$	——	3.90	2.81

The figures for construction investment are higher than those for machinery and equipment investment, which is consistent with the idea that construction investment is more sensitive to political instability, as suggested in Section 1.

Another way of capturing the size of the political instability effects is to calculate the implicit increase in investment if the instability were to be removed completely; that is, if all three instability measures fell to zero. In other words, we can estimate the impact of a discontinuation of all Palestinian attacks on Israelis (ISRK = 0), plus a discontinuation of all demonstrations leading to Israeli security forces killing Palestinians (ALLK = 0), plus a cessation of increases in the rate of expansion of Jewish settlements in the West Bank and Gaza areas (Δln(CWBG) = 0). This is one way of quantifying the "peace dividend" for investment, though it must be stressed that the Table 2 regressions rely only on the weak exogeneity of the explanatory variables. Our calculations ignore any second-order effects, for example the possibility that peace will increase output in Israel, either through higher investment or through other channels. The calculations are a first-order approximation of the peace dividend for investment.[11]

The average total number of politically related deaths in Israel over the sample period has been 42.47 per quarter; the average number of Israeli deaths has been 10.74 per quarter. Were these figures to fall from their average levels straight to zero, investment in non-residential construction would immediately rise by 2.7% and machinery and equipment investment by 6.3%. In the steady-state, ignoring any effect via changes in the weakly

[10] So for example the first element in the table measures the ML estimate of sd(ISRK)$\cdot \left| f^B{}_1/(1 - \Sigma_\tau g^B{}_\tau) \right|$ from equation (2). This is a hypothetical exercise, since the *ceteris paribus* assumption for the other regressors in each equation would never actually hold: at the very least, investment in the other type of capital good would be changing.

[11] Although the calculations assume no change in the weakly exogenous regressors, they do include the interaction between I^B and I^M implicit in the system described by Table 3.

exogenous regressors, construction investment would be 24.6% higher than otherwise and machinery and equipment investment 14.6% higher than otherwise. The average rate of growth of house building in the West Bank and Gaza areas in the sample period has been 3.07% per quarter. Were this figure to fall from its average level straight to zero, construction investment would immediately rise by 0.46% and machinery and equipment investment by 0.20%. In the steady-state, ignoring any effect via changes in the weakly exogenous regressors, construction investment would be 2.73% higher than otherwise and machinery and equipment investment 1.09% higher than otherwise.

The investment equations are conditioned on contemporaneous fatality statistics, and a potential criticism of the model is that political instability and unrest may depend on the current level of economic activity, of which investment demand is one component. Khawaja (1993, 1995) uses panel data on the incidence of uprisings in different parts of the West Bank in order to explore the determinants of the intensity of the *Intifada*. He does not include any explicitly economic variables, but is able to explain a large part of the sample variance by using geographical characteristics, the intensity of past activity by the local Israeli security forces, and schooling. These results suggest, but do not prove, that the intensity of the *Intifada* has depended largely on social and political factors rather than on economic ones. In order to test the hypothesis that our variables ISRK and ALLK are weakly exogenous to investment, we employ the method outlined by Engle and Hendry (1993). The investment equation residuals u^i_t are added to regressions for each of the two fatality series, using lags of $ISRK_t$ and $ALLK_t$ as instruments. The F-test for the joint significance of the u^i_t in the ISRK regression constitutes a test of the joint hypothesis that ISRK is weakly exogenous to both types of investment; the same logic applies to ALLK. These F-statistics are reported in Table 5. Also in Table 5 are F-statistics for the individual significance of each investment equation residual in each fatality regression, testing the null hypotheses (i) that ISRK is weakly exogenous to I^B and (ii) that it is weakly exogenous to I^M, and similarly for ALLK. None of these statistics is significant at the 10% level, so we have no grounds for rejecting the assumption that the fatality statistics are weakly exogenous variables.

Table 3 also shows the impact on investment of the Oslo Peace Accord, and of the Labour Party election victory in 1992 and defeat in 1996, as captured by the dummy variables OSLO, LABIN and LABOUT. As anticipated, investment is lower after the accord, *ceteris* *paribus*. The impact effect of the accord on construction investment is a 24.0% fall; the corresponding figure for machinery and equipment investment is 6.5%. These differences again suggest a greater sensitivity to perceived political instability in construction investment. It is important to remember, however, that the accord may represent a consequence of political uncertainty rather than a cause. And if the Oslo agreement introduced uncertainty about the future structure of the Israeli and Palestinian polity, future agreements that resolve this structure might well reduce perceived political uncertainty and stimulate higher investment, in addition to the increase due to reduced political unrest.

The period of Labour Party government corresponded to a significantly higher investment rate in construction, but not in machinery and equipment. The impact effect of the Labour Party victory in 1992 was an 11.1% increase in construction investment; the impact of its defeat in 1996 was a 15.3% reduction in construction investment. One possible explanation for this effect is a perception that the extreme right is less influential under labour rule, and that this reduces perceived political instability; however, the effect might also be partially explained by economic policies more favourable to investment.

5. Summary and Conclusion

It has been possible to estimate a statistically robust quarterly time-series model of investment in Israel for the period 1988-1998, disaggregating investment into non-residential construction and machinery and equipment. This model is based on a standard economic representation of a profit-maximising firm, but also incorporates time series reflecting the degree of political instability in Israel following the *Intifada*. The construction of these series is motivated by recent political science research into the factors affecting perceived political uncertainty in Israel.

Amongst the economic factors explaining variations in investment over time, the strongest effects are through the real wage rate and aggregate demand; capital cost variables explain a relatively small part of the variation. There is also a strong complimentarity between investment in different types of capital good, although there are substantial differences in the dynamics of the equations representing the two types of investment.

The most important time-varying factor reflecting political instability and risk is the number of people killed in *Intifada*-related attacks. Both the number of Israelis killed by

Palestinian paramilitaries and the number of Palestinians killed by Israeli security forces affect aggregate investment. Although the effects are asymmetrical, in that there are significantly different consequences of a change in the Israeli fatality figures as compared with a change in the total fatality figures, violence of all kinds depresses investment demand. So a substantial improvement in investment performance will arise not from increasingly Draconian Israeli security measures (which might reduce Israeli fatalities but which are likely, if anything, to increase the number of Palestinian casualties) but only from a peace agreement which removes the incentive for violent political conflict. We calculate estimates of the increase in investment that would occur if there were a lasting peace. The size of the increase is substantial.

Other political factors which have influenced aggregate investment are the Oslo Peace Accord, general elections and the rate of growth of Jewish settlements in the West Bank and Gaza areas. The effect of settlement growth is negative, although the impact on investment of a cessation of the expansion of the settlements would probably be quite small in comparison with the impact of an end to political violence.

The results of this paper are consistent with previous cross-country work on the impact of political instability on investment. But the sensitivity of investment to time-varying political instability variables in a quarterly model emphasises the fact that differences in economic performance between countries may lie as much in short-term political factors over which policymakers potentially have some direct influence as in indices of democracy and other long term structural characteristics of the polity.

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Appendix 1

In this appendix we derive the theoretical model used in Section 2; this is an extension of the model used in Rama (1993). There are two types of capital investment in the model: non-residential construction (B) and machinery / equipment (M). The optimal level for each type of capital is that which maximises the growth in the value of the firm, Π. Π is given by:

$$\Pi = [p_t \cdot q_t - w_t \cdot n_t] + \{p_{t+1} \cdot q_{t+1} - E[w_{t+1}] \cdot n_{t+1}\}/[1 + r_t] - \Sigma_i v^i_t \cdot I^i_t \qquad \text{(A1)}$$
$$+ \Sigma_i \{E[v^i_{t+1}] \cdot k^i_{t+1}/[1 + r_t] - v^i_t \cdot k^i_t\} + \{v^i_t \cdot k^i_t - v^i_{t-1} \cdot k^i_{t-1} \cdot [1 + r_{t-1}]\}$$

where q_t is the firm's output at t, p_t the price of this output, w_t wages, n_t employment, r_t the nominal interest rate, k^i_t the stock of the i^{th} type of capital, I^i_t gross investment in this type of capital, v^i_t the price of this type of capital good and E[ ] an expectations operator. The firm chooses k_{t+1}, n_{t+1}, q_{t+1} and (with imperfect competition) p_{t+1}. The first two bracketed terms represent the present discounted value of present and future operating profits. The third term represents the cost of acquiring new capital goods. The final two terms represent discounted capital gains from changes in the value of the firm's capital stock over the two periods.

Neither the first nor the last term in equation (A1) is dependent on current investment, and will not affect the maximisation problem. Defining these terms as z_t, we can write:

$$\Pi = z_t + \{p_{t+1} \cdot q_{t+1} - E[w_{t+1}] \cdot n_{t+1}\}/[1 + r_t] - \Sigma_i v^i_t \cdot I^i_t \qquad \text{(A2)}$$
$$+ \Sigma_i \{E[v^i_{t+1}] \cdot k^i_{t+1}/[1 + r_t] - v^i_t \cdot k^i_t\}$$

The stock of the i^{th} type of capital is related to gross investment by the following law of motion:

$$k^i_{t+1} = [k^i_t + I^i_t]/[1 + \delta] \qquad \text{(A3)}$$

δ is the rate of capital depreciation. Substituting equation (A3) into equation (A2):

$$\Pi = z_t + \{p_{t+1} \cdot q_{t+1} - \Sigma_i E[c^i_{t+1}] \cdot k^i_{t+1} - E[w_{t+1}] \cdot n_{t+1}\}/[1 + r_t] \qquad \text{(A4)}$$

where c_t is the user cost of capital net of a capital gains term:

$$c^i_{t+1} = [r_t + \delta + r_t \cdot \delta] \cdot v^i_t - [v^i_{t+1} - v^i_t] \qquad \text{(A5)}$$

In order to derive a tractable solution for the optimal capital stock, we will assume that output is a log-linear function of employment and the firm's stock of each type of capital. We introduce adjustment costs by allowing output to depend negatively on the rate of growth of capital (productivity is lower when new capital is being installed):

$$q_t = \theta \cdot k^{B\ \alpha}_t \cdot k^{M\ \gamma}_t \cdot n_t^{\beta} \cdot (k^B_t/k^B_{t-1})^{-\phi} \cdot (k^M_t/k^M_{t-1})^{-\psi} \qquad \text{(A6)}$$

$$1 > \alpha > \phi > 0,\ 1 > \beta > 0,\ 1 > \gamma > \psi > 0,\ \theta > 0 \text{ and } \alpha + \beta + \gamma - \phi - \psi \leq 1$$

The parameter restrictions embody neoclassical assumptions. We will also allow demand for the firm's output to depend negatively on its relative price. The demand curve faced by the firm is of the form:

$$q_t = [Q_t/J_t] \cdot [p_t/P_t]^{-\sigma},\ \sigma > 1 \qquad \text{(A7)}$$

where Q_t is aggregate demand in the economy, P_t the average price level and J_t the number of firms in the economy. $\sigma > 1$ is required to ensure that the firm's revenue ($p_t \cdot q_t$) is decreasing in its output price. As $\sigma \to \infty$ the economy becomes perfectly competitive and goods perfectly homogenous.

Substituting equations (A6-A7) into equation (A2) we have:

$$\Pi = z_t + \{p_{t+1}^{1-\sigma} \cdot E[(Q/J)_{t+1}] \cdot E[P_{t+1}]^{\sigma} - \Sigma_i E[c^i_{t+1}] \cdot k^i_{t+1} \qquad \text{(A8)}$$

$$- E[w_{t+1}] \cdot [\theta^{-1} \cdot k^{B\ -\phi}_t \cdot k^{M\ -\psi}_t \cdot E[(Q/J)_{t+1}] \cdot p_{t+1}^{-\sigma} \cdot E[P_{t+1}]^{\sigma} \cdot k^{B\ \ \phi-\alpha}_{t+1} \cdot k^{M\ \ \psi-\gamma}_{t+1}]^{1/\beta}\}/[1 + r_t]$$

Maximising Π with respect to k^B_{t+1}, k^M_{t+1} and p_{t+1} yields the following solutions for k^i_{t+1}, expressed in logarithms:

$$\ln(k^B_{t+1}) = [\ln(\alpha - \phi) - \ln(E[c^B_{t+1}/P_{t+1}])] \cdot [(\alpha - \phi) \cdot (A + (\beta + \gamma - \psi)^{-1}) + 1] \qquad \text{(A9)}$$

$$+ [\ln(\beta) - \ln(E[w_{t+1}/P_{t+1}])] \cdot \beta \cdot A + [\ln(\gamma - \psi) - \ln(E[c^M_{t+1}/P_{t+1}])] \cdot [\gamma - \psi] \cdot A$$

$$+ [\theta + \phi \cdot \ln(k^B_t) + \psi \cdot \ln(k^B_t)] + \ln(E[Q/J]_{t+1}) \cdot (\sigma - 1) \cdot A + \ln[(\sigma - 1)/\sigma] \cdot \sigma \cdot A$$

$$\ln(k^M_{t+1}) = [\ln(\gamma - \psi) - \ln(E[c^M_{t+1}/P_{t+1}])] \cdot [(\gamma - \psi) \cdot (A + (\alpha + \beta - \phi)^{-1}) + 1] \qquad \text{(A10)}$$

$$+ [\ln(\beta) - \ln(E[w_{t+1}/P_{t+1}])]\cdot\beta\cdot A + [\ln(\alpha - \phi) - \ln(E[c^B_{t+1}/P_{t+1}])]\cdot[\alpha - \phi]\cdot A$$
$$+ [\theta + \phi\cdot\ln(k^B_t) + \psi\cdot\ln(k^B_t)] + \ln(E[Q/J]_{t+1})\cdot(\sigma - 1)\cdot A + \ln[(\sigma - 1)/\sigma]\cdot\sigma\cdot A$$

where $A = [\sigma - 1]/[\sigma - (\sigma - 1)\cdot(\alpha + \beta + \gamma - \phi - \psi)] > 0$. In other words, the optimal capital stock is a log-linear function of the real user cost of each type of capital, the real wage rate, the average firm output level and the existing stock of each type of capital. Letting $C^i_t = c^i_t/P_t = (v^i_t/P_t)\cdot(r_t + \delta + r_t\cdot\delta - \Delta v^i_t/v^i_t)$, $W^i_t = w^i_t/P_t$ and $Y_t = Q_t/J_t$, the equation has the form:

$$\ln(k^i_{t+1}) = a^i_0 + a_1\cdot\ln(k^B_t) + a_2\cdot\ln(k^M_t) + a^i_3\cdot\ln(E[C^B_{t+1}]) \qquad \text{(A11)}$$
$$+ a^i_4\cdot\ln(E[C^M_{t+1}]) + a_5\cdot\ln(E[W_{t+1}]) + a_6\cdot\ln(E[Y_{t+1}])$$
$$i = B,M;\ a_1, a_2, a_6 > 0 > a^i_2, a^i_3, a^i_4, a_5$$

N.b. the intercept a^i_0 may exhibit some seasonality, if the efficiency parameter θ varies from one season to another (for example, because of seasonal fluctuations in agricultural productivity). We only have quarterly data on gross investment, not on the net capital stock. The two will be related by the equation:

$$k^i_{t+1} = \sum_{\tau=0}^{\tau=\infty} (1 - \delta)^{\tau}\cdot I^i_{t-\tau} \qquad \text{(A12)}$$

and hence:

$$I^i_t = k^i_{t+1} - \sum_{\tau=1}^{\tau=\infty} (1 - \delta)^{\tau}\cdot I^i_{t-\tau} \qquad \text{(A13)}$$

We will assume that this equation has a logarithmic approximation of the form:

$$\ln(I^i_t) = \pi\cdot\ln(k^i_{t+1}) + (1 - \pi)\cdot[\sum_{\tau=1}^{\tau=\infty} \lambda_\tau\cdot\ln(I^i_{t-\tau})] \qquad \text{(A14)}$$

and hence:

$$\ln(I^B_t) = \pi\cdot[a^B_0 + a^B_3\cdot\ln(E[C^B_{t+1}]) + a^B_4\cdot\ln(E[C^M_{t+1}]) \qquad \text{(A15)}$$
$$+ a_5\cdot\ln(E[W_{t+1}]) + a_6\cdot\ln(E[Y_{t+1}])] + [(1 - \pi)\cdot\lambda_1 + a_1]\cdot\ln(I^B_{t-1}) + a_2\cdot\ln(I^M_{t-1})$$
$$+ (1 - \pi)\cdot[\sum_{\tau=2}^{\tau=\infty} (\lambda_\tau + a_1\cdot\lambda_{\tau-1})\cdot\ln(I^B_{t-\tau}) + a_2\cdot\lambda_{\tau-1}\cdot\ln(I^M_{t-\tau})]$$

$$\ln(I^M_t) = \pi\cdot[a^M_0 + a^M_3\cdot\ln(E[C^B_{t+1}]) + a^M_4\cdot\ln(E[C^M_{t+1}]) \qquad \text{(A16)}$$

$$+ a_5 \cdot \ln(E[W_{t+1}]) + a_6 \cdot \ln(E[Y_{t+1}])] + [(1 - \pi) \cdot \lambda_1 + a_2] \cdot \ln(I^M_{t-1}) + a_1 \cdot \ln(I^B_{t-1})$$

$$+ (1 - \pi) \cdot [\sum_{\tau=2}^{\tau=\infty} (\lambda_\tau + a_2 \cdot \lambda_{\tau-1}) \cdot \ln(I^M_{t-\tau}) + a_1 \cdot \lambda_{\tau-1} \cdot \ln(I^B_{t-\tau})]$$

With Rational Expectations, differences between the expected value of a variable, x, and its actual level will be entirely random:

$$\ln(E[x_{t+1}]) = \ln(x_{t+1}) + u^x_{t+1} \qquad \text{(A17)}$$

where u^x_t is an i.i.d. random variable. We will not assume Rational Expectations, but allow a more general characterisation of expectations in which it is possible (though not necessary) that people make systematic prediction errors when x is changing:

$$\ln(E[x_{t+1}]) = \ln(x_{t+1}) + \zeta_x \cdot \Delta\ln(x_{t+1}) + u^x_{t+1} \qquad \text{(A18)}$$

As ζ_x gets larger in absolute value, the systematic errors increase in size. We will allow for separate expectations formation processes for the variables $\ln(Y)_t$, $\ln(W)_t$ and the two additive components of $\ln(C)_t$: $\ln(v^i_t/P_t)$ and $\ln(r_t + \delta + r_t \cdot \delta - \Delta v^i_t/v^i_t)$, written below as $\ln(P^i)_t$ and $\ln(C')_t$. Substituting the expectations formation equations into equations (A15-A16) yields investment equations of the form of equation (1) in the main text:

$$\ln(I^i)_t = b^i_0 + b^i_1 \cdot \ln(C')_t + b^i_2 \cdot \Delta\ln(C')_t + b^i_3 \cdot \ln(P^B)_t + b^i_4 \cdot \Delta\ln(P^B)_t \qquad \text{(A19)}$$

$$+ b^i_5 \cdot \ln(P^M)_t + b^i_6 \cdot \Delta\ln(P^M)_t + b^i_7 \cdot \ln(W)_t + b^i_8 \cdot \Delta\ln(W)_t + b^i_9 \cdot \ln(Y)_t + b^i_{10} \cdot \Delta\ln(Y)_t$$

$$+ \Sigma_\tau\, g^i_\tau \cdot \ln(I^B)_{t-\tau} + \Sigma_\tau\, h^i_\tau \cdot \ln(I^M)_{t-\tau} + u^i_t$$

$$i = B,M;\ b^i_1, b^i_3, b^i_5, b^i_7 < 0 < b^i_9$$

In terms of equations (A15-A18), the parameters in equation (A19) are:
$b^i_0 = \pi \cdot a^i_0$, $b^i_1 = \pi \cdot [a^i_3 + a^i_4]$, $b^i_2 = \pi \cdot \zeta_{C'} \cdot [a^i_3 + a^i_4]$, $b^i_3 = \pi \cdot a^i_3$, $b^i_4 = \pi \cdot \zeta_{PB} \cdot a^i_3$, $b^i_5 = \pi \cdot a^i_4$,
$b^i_6 = \pi \cdot \zeta_{PM} \cdot a^i_4$, $b^i_7 = \pi \cdot a^i_5$, $b^i_8 = \pi \cdot \zeta_W \cdot a^i_5$, $b^i_9 = \pi \cdot a^i_6$, $b^i_{10} = \pi \cdot \zeta_Y \cdot a^i_6$, $g^B_\tau = (1 - \pi) \cdot (\lambda_\tau + a_1 \cdot \lambda_{\tau-1})$, $g^M_\tau = (1 - \pi) \cdot a_2 \cdot \lambda_{\tau-1}$, $h^B_\tau = (1 - \pi) \cdot a_1 \cdot \lambda_{\tau-1}$, $h^M_\tau = (1 - \pi) \cdot (\lambda_\tau + a_2 \cdot \lambda_{\tau-1})$,
$u^i_t = [a^i_3 + a^i_4] \cdot u^{C'}_t + a^i_3 \cdot u^{PB}_t + a^i_4 \cdot u^{PM}_t + a^i_5 \cdot u^W_t + a^i_6 \cdot u^Y_t$

Appendix 2

Economic data are taken from the Israeli Central Bureau of Statistics' *Monthly Bulletin of Statistics*, as provided on the CBS website (http://www.cbs.gov.il). The series are defined as follows:

I^B	investment in non-residential construction, thousands of 1998 Shekels
I^M	investment in machinery and non-transport equipment, thousands of 1998 Shekels
Y	gross domestic product (GDP), thousands of 1998 Shekels
W	economy-wide average wage rate ÷ gross domestic product deflator
P^B	deflator for investment in non-residential construction ÷ GDP deflator
P^M	deflator for investment in machinery and non-transport equipment ÷ GDP deflator

The capital cost series C' is defined in Appendix 1 as $[r_t + \delta + r_t \cdot \delta - \Delta v^i_t / v^i_t]$, that is, the nominal interest rate plus the rate of capital depreciation, plus their product less the rate of capital good price inflation. Measurement of r_t in Israel is complicated because the yield on government bonds (which gives the highest real rate of return of any financial security) is indexed-linked: the bond yield is a real interest rate. We take the 10-year bond yield as our measure of $[r_t - \Delta v^i_t / v^i_t]$, though this is an approximation because the indexing is to general inflation rather than to capital good price inflation. We assume that $\delta = 1.5\%$ per quarter: the $\ln(C')_t$ series exhibits very little variation if this number is increased to 2.5% or reduced to 0.5%. Then we approximate $r_t \cdot \delta$ as [bond yield]·[consumer price inflation]·0.015. This last component of C' is very small, and makes no noticeable difference to the properties of the series

Appendix 3 **Table A1: The Unrestricted Investment Model**

Δln(IB)

variable	coeff.	std. err.	t ratio	prob.
Δln(IB)$_{-1}$	-0.78338	0.25202	-3.108	0.0072
Δln(IB)$_{-2}$	-0.75401	0.24591	-3.066	0.0078
Δln(IB)$_{-3}$	-0.65649	0.23293	-2.818	0.0130
Δln(IB)$_{-4}$	0.20781	0.17546	1.184	0.2547
Δln(IM)$_{-1}$	-0.17168	0.42628	-0.403	0.6928
Δln(IM)$_{-2}$	0.31459	0.30747	1.023	0.3225
Δln(IM)$_{-3}$	0.09426	0.25466	0.370	0.7165
Δln(IM)$_{-4}$	0.07317	0.18075	0.405	0.6913
ecmM$_{-1}$	0.07606	0.57157	0.133	0.8959
ecmB$_{-1}$	-0.26933	0.24012	-1.122	0.2796
Δln(Y)$_{-1}$	0.88169	0.82602	1.067	0.3027
Δln(W)$_{-1}$	0.00206	0.97658	0.002	0.9983
Δln(C')$_{-1}$	-0.56771	0.48964	-1.159	0.2644
Δln(PB)$_{-1}$	-0.87094	0.85082	-1.024	0.3222
Δln(PM)$_{-1}$	-0.15693	0.61143	-0.257	0.8009
ln(PB)$_{-1}$	0.36903	0.80209	0.460	0.6521
ln(PM)$_{-1}$	-0.61839	0.54799	-1.128	0.2768
Δln(CWBG)$_{-4}$	-0.13982	0.04665	-2.998	0.0090
ISRK	-2.08240	1.24920	-1.667	0.1162
ALLK	-0.36548	1.06170	-0.344	0.7355
LABIN	0.13483	0.05675	2.376	0.0313
OSLO	-0.25665	0.06459	-3.974	0.0012
LABOUT	-0.13887	0.07283	-1.907	0.0759
Constant	-4.44160	7.21350	-0.616	0.5473
Seasonal Dummy 1	-0.00407	0.08777	-0.046	0.9636
Seasonal Dummy 2	-0.06049	0.09844	-0.614	0.5481
Seasonal Dummy 3	-0.10574	0.06948	-1.522	0.1488

σ = 0.06294 RSS = 0.05943

Δln(IM)

variable	coeff.	std. err.	t ratio	prob.
Δln(IB)$_{-1}$	-0.54485	0.27838	-1.957	0.0692
Δln(IB)$_{-2}$	-0.49529	0.27162	-1.823	0.0882
Δln(IB)$_{-3}$	-0.30799	0.25728	-1.197	0.2498
Δln(IB)$_{-4}$	-0.09927	0.19380	-0.512	0.6159
Δln(IM)$_{-1}$	-0.00709	0.47085	-0.015	0.9882
Δln(IM)$_{-2}$	0.21980	0.33962	0.647	0.5273
Δln(IM)$_{-3}$	0.36808	0.28129	1.309	0.2104
Δln(IM)$_{-4}$	0.28932	0.19965	1.449	0.1679
ecmM$_{-1}$	-0.95218	0.63134	-1.508	0.1523
ecmB$_{-1}$	0.35338	0.26523	1.332	0.2026
Δln(Y)$_{-1}$	0.11770	0.91239	0.129	0.8991
Δln(W)$_{-1}$	-1.72590	1.07870	-1.600	0.1304
Δln(C')$_{-1}$	-0.41810	0.54084	-0.773	0.4515
Δln(PB)$_{-1}$	0.68020	0.93979	0.724	0.4803
Δln(PM)$_{-1}$	-0.26078	0.67537	-0.386	0.7048
ln(PB)$_{-1}$	-0.77264	0.88596	-0.872	0.3969
ln(PM)$_{-1}$	0.42277	0.60529	0.698	0.4956
Δln(CWBG)$_{-4}$	-0.07077	0.05152	-1.374	0.1897
ISRK	0.66092	1.37980	0.479	0.6391
ALLK	-2.35381	1.17280	-2.007	0.0632
LABIN	0.04797	0.06268	0.765	0.4560
OSLO	-0.10781	0.07134	-1.511	0.1515
LABOUT	-0.02062	0.08044	-0.256	0.8012
Constant	-5.82950	7.96780	-0.732	0.4757
Seasonal Dummy 1	0.14156	0.09695	1.460	0.1649
Seasonal Dummy 2	0.04588	0.10873	0.422	0.6790
Seasonal Dummy 3	-0.08694	0.07674	-1.133	0.2751

σ = 0.06953 RSS = 0.07251

Table A1 (Continued)

Unrestricted System Statistics
joint significance of regressors: $F(54,28) = 5.4134$ [0.0000]
$\ln(L) = 273.96$ $\ln|\Omega| = -13.046$ $R^2(LM) = 0.88773$
cross- equation residual correlation = 0.34077
SBC = -8.240 HQC = -9.656 AIC = -10.474

Table A2: SUR Estimates of the Restricted Model

$\Delta\ln(IB)$

variable	coeff.	std. err.	t ratio	prob.
$\Delta\ln(IB)_{-1}$	-0.68372	0.17799	-3.841	0.0008
$\Delta\ln(IB)_{-2}$	-0.64397	0.16156	-3.986	0.0005
$\Delta\ln(IB)_{-3}$	-0.59111	0.14938	-3.957	0.0006
$\Delta\ln(IB)_{-4}$	0.22467	0.12124	1.853	0.0762
$\Delta\ln(IM)_{-1}$	-0.51430	0.17424	-2.952	0.0070
$ecmM_{-1}$	0.53989	0.27388	1.971	0.0603
$ecmB_{-1}$	-0.41432	0.16959	-2.443	0.0223
$\Delta\ln(Y)_{-1}$	0.79012	0.56451	1.400	0.1744
$\Delta\ln(C')_{-1}$	-0.75618	0.31847	-2.374	0.0259
$\Delta\ln(PB)_{-1}$	-0.86898	0.44168	-1.967	0.0608
$\ln(PM)_{-1}$	-0.53403	0.22351	-2.389	0.0251
$\Delta\ln(CWBG)_{-4}$	-0.14982	0.03579	-4.186	0.0003
ISRK	-2.47330	0.94898	-2.606	0.0155
LABIN	0.11245	0.04076	2.759	0.0109
OSLO	-0.24248	0.04652	-5.212	0.0000
LABOUT	-0.15706	0.04818	-3.260	0.0033
Constant	-0.84978	4.29230	-0.198	0.8447
Seasonal Dummy 1	-0.02097	0.05896	-0.356	0.7252
Seasonal Dummy 2	-0.09205	0.07071	-1.302	0.2053
Seasonal Dummy 3	-0.12464	0.05033	-2.476	0.0207

$\sigma = 0.05324$

$\Delta\ln(IM)$

variable	coeff.	std. err.	t ratio	prob.
$\Delta\ln(IB)_{-1}$	-0.34613	0.15436	-2.242	0.0344
$\Delta\ln(IB)_{-2}$	-0.23118	0.11690	-1.978	0.0596
$\Delta\ln(IM)_{-1}$	0.03036	0.23718	0.128	0.8992
$\Delta\ln(IM)_{-2}$	0.19775	0.20330	0.973	0.3404
$\Delta\ln(IM)_{-3}$	0.25947	0.15934	1.628	0.1165
$\Delta\ln(IM)_{-4}$	0.26796	0.15360	1.744	0.0939
$ecmM_{-1}$	-0.96282	0.33053	-2.913	0.0076
$ecmB_{-1}$	0.30971	0.17581	1.762	0.0909
$\Delta\ln(W)_{-1}$	-1.57710	0.71771	-2.197	0.0379
$\Delta\ln(CWBG)_{-4}$	-0.06290	0.03573	-1.760	0.0911
ALLK	-1.50520	0.58027	-2.594	0.0159
OSLO	-0.06509	0.02812	-2.315	0.0295
Constant	-6.96670	4.44200	-1.568	0.1299
Seasonal Dummy 1	0.05110	0.03860	1.324	0.1980
Seasonal Dummy 2	-0.03556	0.05366	-0.663	0.5138
Seasonal Dummy 3	-0.11249	0.04736	-2.375	0.0259

$\sigma = 0.06180$

Restricted System Statistics
joint restrictions test: $\chi^2(26) = 23.421$ [0.6090]
$\ln(L) = 265.91$ $\ln|\Omega| = -12.662$ SBC = -9.458 HQC = -10.402 AIC = -10.948
cross-equation residual correlation = 0.32164
system error normality: $\chi^2(4) = 4.1802$ [0.3822]
system error autocorrelation (order 1): $F(4,42) = 0.92675$ [0.4576]
system error autocorrelation (order 4): $F(16,30) = 1.73370$ [0.0942]
$\Delta\ln(IB)$ equation ARCH (order 1): $F(1,9) = 0.25065$ [0.6286]
$\Delta\ln(IM)$ equation ARCH (order 1): $F(1,9) = 0.00507$ [0.9448]
$\Delta\ln(IB)$ equation ARCH (order 4): $F(4,3) = 0.05636$ [0.9911]
$\Delta\ln(IM)$ equation ARCH (order 4): $F(4,3) = 0.04282$ [0.9946]