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DUAL EXCHANGE RATE RISK IN DUAL STOCKS

BEN Z. SCHREIBER*

Abstract

This study examines international dual stocks' exposure to two types of exchange rate effects/risks. One is an arbitrage effect and a deviation from the Law of One Price (LOOP). This is a simultaneous effect, is influenced by factors relating to the structure of the market and results in a stock having two different returns. The other effect is the economic risk in which a continual change in the exchange rate affects the company's earnings and thereby the return on the investment and it is derived from the basic characteristics of the company—an export company is exposed to appreciation while an import company is exposed to depreciation. Accordingly, economic risk should affect stock prices in both stock markets in the same direction and to the same extent, but with a lag.

Economic risk is the effect which should be of interest to long-term investors and policy makers. However, it is not easy to estimate this risk because in many cases international dual-listed stocks are notable for deviation from the LOOP, meaning that they yield two different returns. The contribution of this study derives from the formulation of two alternative ways for estimating the effect of the economic risk exclusive of the arbitrage effect.

These two alternatives were estimated on the monthly returns of 14 dual-listed stocks in Israel during the period 1/2004–12/2011. It was found that the economic risk had a significant negative effect on the stock rate of return of import companies, while its effect on export companies' stock rates of return was ambiguous. This result can be attributed to the fact that relative to the importers, the export companies in the sample were heterogeneous and partially hedged their activity.

* Bank of Israel, Information and Statistics Department and Bar-Ilan University.
Email: schreiber.ben@boi.org.il,

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1. INTRODUCTION

The number of Israeli companies whose stocks are dual listed—traded simultaneously on the Tel Aviv Stock Exchange and in another global stock market such as the NASDAQ—increased during recent years. In 2011, 60 out of the 600 stocks traded in Tel Aviv were dual listed, and they accounted for a third of the market value of all Israeli equities. Israeli and foreign residents' investment in these stocks on the Tel Aviv Stock Exchange and in foreign markets (usually via ADR, American Depository Receipts) increased concurrently.

The foreign currency market in Israel is affected by the activity of dual-listed companies that import and export goods and services. In many cases however, it is unclear whether dual-listed companies should be included among those that affect and are affected by the foreign currency market. This is because the extent of these companies' exposure to the exchange rate has not been known until now. It is therefore important to estimate dual-listed stocks' exposure to the exchange rate and thereby increase the understanding of the forces influencing the local foreign currency market.

An assumption prevalent in studies that attempt to estimate the rate of return of dual-listed stocks is that there is no arbitrage opportunity, meaning that the price of a dual-listed stock in Tel Aviv is equal to the price of the stock in the US multiplied by the shekel/dollar exchange rate. This phenomenon is also known as the Law of One Price (LOOP). In practice, LOOP deviations exist, due, for example, to differences in the preferences of investors in the two stock markets and to liquidity gaps, especially in periods of turbulent trading.[1] An estimation regarding a dual-listed stock rate of return in the local market is therefore likely to produce a different result when applied to such a stock in the US market. This study offers two ways of estimating the cumulative economic effect exerted by the exchange rate (economic risk) on the rate of return of a dual-listed stock, exclusive of the arbitrage effect and any deviation from the Law of One Price.

The sample in this study contains new, and to the extent possible, simultaneous data on four factors—the Tel Aviv 100 Index return, the NASDAQ Composite Index return, the changes in the shekel/dollar exchange rate, and the rate of return of the 14 leading Israeli stocks traded in Tel Aviv and on the NASDAQ (10 exporters and 4 local importers/manufacturers)—from the period between 1/2004 and 12/2011. It was found that the economic effect of the shekel/dollar exchange rate was significantly negative in the case of importers, and mixed in the case of exporters: With part of the exporters a significant positive effect was found, as expected, and with some of them a negative but usually insignificant effect was found. The conclusion to be drawn from the analysis is that importers are notable for homogeneous exposure to economic risk, while exporters are heterogeneous in their exposure to the economic risk either because part of them hedge against it or because their base currency is the dollar.

The rest of the study is organized as follows: Section 2 reviews the literature. Section 3 presents a methodology for estimating the effects of arbitrage and economic risk on the rate

[1] A theoretical model of the arbitrage effect on rates of return, such as CAPM with a liquidity premium, does not conform to the objectives of the present study.

of return on a dual-listed stock. Section 4 describes the data, Section 5 presents the results of the regressions and Section 6 concludes.

2. REVIEW OF THE LITERATURE

The literature relevant to this study generally deals with two main subjects. First, it examines whether there is a gap between the rates of return of a dual-listed stock in the two markets in which it is traded. Second, it estimates the exposure to the exchange rate of companies with international activity and especially importers/exporters, regardless of whether or not the stock is dual-listed.

As regards the first subject, it is usually assumed that no arbitrage opportunity exists in efficient markets. Yet, it is found that the gap between the prices of the same company that traded in the two markets is small to the extent merely of bid/ask spreads and/or is quickly closed. This assumption has become stronger over the years due to machine trading and algo trading, as these types of trading lead to the closure of arbitrage gaps within milliseconds. Gagnon and Karolyi (2010) showed that this assumption is generally valid. These authors referred to a sample of 506 dual-listed American stocks that are traded in 35 different countries, and found that the LOOP deviation amounted to 4.9 basis points. However, there were days when the gaps were larger. This appears to have occurred mainly when no bid/ask quotations were given and normal trading was therefore not possible, or when liquidity was low.

The reasons for the price disparities in dual-listed stocks include liquidity gaps, especially in periods of financial crisis, the varying degrees of efficiency at which information on the dual-listed company is transferred, transaction costs differentials and taxation differences between the markets, regulatory restrictions, non-simultaneous trading and differing preferences among investors, especially home bias, which reflects a preference for investing in the local market rather than in foreign markets (see Turnbull el al. 2010; Gupta 2010; Pasquariello 2008; Chan et al., 2008; Kwon et al., 2005; Baruch et al., 2007; Agarwal et al., 2007)

The situation in Israel is similar. Lieberman et al. (1999) found that hardly any arbitrage opportunities exist with dual-listed Israeli stocks, and that the performance of stocks at the time of simultaneous trading (Monday through Thursday) differed from their performance on weekends.

Kwon et al. (2005) distinguish between translation risk and economic risk in dual-listed stocks. Translation risk derives from a potential change in the exchange rate when a foreign resident sells the stock in the local economy or when a local resident sells the stock in a global stock market. Economic risk derives from the cumulative effect of the exchange rate on the earnings of the company whose stocks are dual-listed regardless of whether the investor is a local or foreign resident. From the investor's viewpoint, although the return in both stock markets is the same, the exchange rate component in the return (all other things being equal) can change according to the stock market. Unlike this study, however, Kwon et al. (2005) did not distinguish between export and import companies, and did not use structural equations to estimate the relationships between the three variables: the price of the stock in the local market, its price in the global market and the exchange rate.

With regard to the second subject—the estimation of exporters' and importers' exposure to the exchange rate—the literature dealing with it does not actually focus on dual-listed stocks. The basic economic understanding is that the stock prices of export (import) companies should increase (decline) as the result of a depreciation of the local currency (Muller and Verschoor 2006). But opinions are divided regarding the manner in which the exchange rate affects the rate of return of stocks as a whole and of dual-listed companies in particular. Some of the authors found that the exchange rate has no major impact on the stock prices of export and import companies. Authors such as Jorion (1991) discovered this in a study of American companies, Griffin and Stulz (2001) in an international study by branches of industry, and Bredin and Hyde (2011) in a study by branches of industry in the G7 countries. However, other authors found that the exchange rate does have a considerable effect on stock prices. This was found, for example, by Patnaik and Shah (2010) in a study of Indian companies, Pasquariello (2008) in a study that examined a number of emerging markets, and Cheng et al. (2010) in a study of Taiwanese companies. The differing results may have derived, *inter alia,* from the fact that the characteristics of developed and closed markets, such as the US market, differ from those of emerging open markets.

Cheng et al. (2010) found that the exchange rate affects stock prices with a lag of up to 4 months. This is in addition to the simultaneous effect, which was the most substantial effect from the aspect of the size of the coefficient and from the aspect of its significance. Kwon et al. (2005) examined the effects of the exchange rate on dual-listed stocks in a number of open economies, and found that foreign investors price exchange-rate risk differently from local investors, and that this pricing varies among different markets.

Priestley and Odegaard (2007) and Muller and Verschoor (2006) emphasize the importance of using a suitable econometric estimation when examining the effect of the exchange rate on stock rates of return. Priestley and Odegaard (2007) found that the exchange rate exerts non-linear and asymmetrical effects on stock rates of return in the principal industries in the US. They also noted that orthogonalization between the exchange rate, the local stock index and the foreign stock index (in which the ADR is traded) is necessary in the estimation. This is because these variables explain the international dual stock rate of return in both markets and are coordinated.

Bartram et al. (2010) refer to the gap between the theory and the empirical evidence. The theoretical exposure is calculated with the help of economic models, and these models predict protection and hedging at far higher rates than those indicated by the empirical evidence. These authors claim that up to 70 percent of the gap can be explained by indirect actions which companies take in order to reduce exchange-rate exposure. Such action can take the form of internal offsets (between export and import flows), passing on the exposure to suppliers and customers, debt issue in foreign currency and protection by means of derivatives.

3. ANALYSIS OF INVESTMENT IN FOREIGN AND DUAL-LISTED STOCKS

a. Analysis of the risks involved in investment in non-dual-listed stocks

To provide a complete presentation, we will begin by examining a non-dual-listed stock, and describe the expected rate of return and the risk involved in investment in a foreign stock. While an investment in a stock traded in the local stock market in shekels is dependent on one random variable—stock rate of return—investment in a foreign stock traded abroad is dependent on two random variables: the stock rate of return and the change in the exchange rate. We will take the case of an Israeli investor (whose base currency is the shekel) and assume that he buys stocks in a foreign company, which are traded in dollars.

We will denote: X—the shekel/dollar spot rate, S—the dollar price of the stock abroad, V—the shekel value of the investment. The rate of return on the investment from now (time 0) to time 1 is:

$$R \equiv \frac{V_1}{V_0} - 1 \cong Ln\left(\frac{V_1}{V_0}\right) = Ln\left(\frac{S_1 X_1}{S_0 X_0}\right) = Ln\left(\frac{S_1}{S_0}\right) + Ln\left(\frac{X_1}{X_0}\right)$$

and the expected rate of return is therefore:

$$\text{(1a)} \quad E(R) = E(\Delta s) + E(\Delta x)$$

where $\Delta x = Ln(X_1/X_0)$, $\Delta s = Ln(S_1/S_0)$, and the variance of the rate of return is:

$$\text{(1b)} \quad Var(R) = Var(\Delta s) + Var(\Delta x) + 2Cov(\Delta s, \Delta x)$$

In a small open economy like Israel, the correlation between the change in the shekel/dollar exchange rate and the return on a foreign stock (Microsoft, for example) is usually zero ($Cov(\Delta s,\Delta x) = 0$) because this return is uncorrelated with the change in the shekel/dollar exchange rate. However, if the foreign company has substantial activity in the local market and is also tradable in it, the correlation cannot be ignored.

b. Analysis of the risks involved in investment in international dual stocks

We will now examine dual-listed stocks. We will take an Israeli industrial company, and assume that its stocks are traded simultaneously in Tel Aviv and on the NASDAQ, and that there is no arbitrage opportunity. We will denote in superscript LM (Local Market) and US (United States) and the local stock market (in shekels) and the NASDAQ (in US dollars) respectively. We will denote in subscript L (Local) and F (Foreign) the identity of the investor—Israeli (whose base currency is the shekel) and foreign (whose base currency is the dollar) respectively. We will initially assume that the two markets are efficient and in particular, will assume that trading in the dual-listed stocks does not permit arbitrage earnings. Then for each point in time t: $S^{LM}/S^{US} = X$, where S^{LM} , S^{US} are the stock prices in shekels and dollars, respectively, and X is the shekel/dollar exchange rate. In terms of rates of change from now (time 0) to time 1, we obtain:

(2) $$\Delta S^{LM} - \Delta S^{US} = \Delta X$$

Where, $\Delta S^{LM} = Ln(S_1^{LM} / S_0^{LM})$, $\Delta S^{US} = Ln(S_1^{US} / S_0^{US})$ is the rate of return of the stock that is traded on the NASDAQ and the shekel price of the stock in Tel Aviv, respectively, and ΔX is the change in the shekel/dollar exchange rate.

According to Equation (2), for each point in time when both stock markets are trading, the ratio between the stock price in Tel Aviv (in shekels) and the stock price on the NASDAQ (in dollars) is the shekel/dollar exchange rate. Any change in the exchange rate is therefore likely to affect the ratio between the prices in the two stock markets regardless of the market's relative size and the volume in it. Any change in the exchange rate (assuming that all else is constant) is likely to lead to a change in the shekel price of the stock in Tel Aviv, a change in the dollar price on the NASDAQ or a change in both prices. (Appendix A contains an example of the effect of a change in the exchange rate on the price of the stock in the two markets.) The reason for this is that in arbitrage activity, the inexpensive stock is bought and the expensive stock is sold simultaneously, until at the end of the process the above-mentioned ratio is obtained, which is the equilibrium ratio that no longer permits arbitrage earnings. Accordingly, three variables—the stock price in Tel Aviv, the stock price on the NASDAQ and the shekel/dollar exchange rate—leave only two degrees of freedom (as a result of the arbitrage). Due to the technological development of machine trading and algo trading, arbitrage gaps (in excess of bid-ask spreads) are closed within milliseconds. However, it should be realized that the assumption concerning the lack of opportunity for arbitrage earnings is valid up to a point (of transaction costs),[2] and on the assumption that transactions can be conducted simultaneously in both markets—meaning that price quotations are available, liquidity and trading in the stock are simultaneous.

According to Equation (1) above, the rate of return on investment in non-dual-listed foreign stocks is dependent on the stock rate of return and on changes in the local economy's exchange rate. However, investment in dual-listed stocks makes the location of trading in the stock irrelevant for the investor, as we will see below. An Israeli investor is faced with two alternatives. The first is to buy a dual-listed stock in Israel, and the other is to convert his money to dollars and buy the stock abroad. In efficient markets, the two alternatives should be equivalent. If arbitrage opportunity does not exist, the (shekel) rate of return on the Israeli's investment (all else being constant) is:

(3) $$\mathrm{R}_{\mathrm{L}}^{\mathrm{LM}} \equiv \ln\left(\frac{\mathrm{S}_1^{LM}}{\mathrm{S}_0^{LM}}\right) = \ln\left(\frac{\mathrm{S}_1^{US} X_1}{\mathrm{S}_0^{US} X_0}\right) = \Delta S^{US} + \Delta X = \mathrm{R}_{\mathrm{L}}^{\mathrm{US}}$$

The foreign investor is also faced with two alternatives, and in efficient markets they are equivalent. The alternatives are to buy the stock on the NASDAQ or to convert the money to shekels and to buy it in Tel Aviv. If arbitrage opportunity does not exist, the (dollar) rate of return on the Israeli's investment (all else being constant) is:

[2] Apart from bid-ask spreads, bid-ask fees and taxation differences.

(4) $$R_F^{US} \equiv \ln\left(\frac{S_1^{US}}{S_0^{US}}\right) = \ln\left(\frac{S_1^{LM}/X_1}{S_0^{LM}/X_0}\right) = \Delta S^{LM} - \Delta X = R_F^{LM}$$

As mentioned above, the rate of return for a local (and foreign) investor in Tel Aviv should be the same as his rate of return on NASDAQ when there is no arbitrage opportunity.[3] Accordingly, if a local investor and a foreign investor operate in the same stock market (Tel Aviv or NASDAQ), the gaps between the rates of return on their investments in dual-listed stocks amounts to the rate of change in the exchange rate.[4] In terms of Equation (2) and on the basis of Equations (3) and (4), we obtain, as expected, equality between the investment returns in the local market and on NASDAQ (excepting the change in the exchange rate), regardless of whether the investor is local or foreign:

(5) $$R^{LM} - R^{US} = \Delta X$$

where R^{US} and R^{LM} represent an Israeli investor's rate of return in the US and in Israel, respectively. Alternatively, and after multiplication of both sides of the equality by -1, they represent the rate of return of an American investor in Israel and in the US, respectively.

c. Deviation from the Law of One Price (LOOP)

In reality a deviation sometimes does actually occur from the non-arbitrage opportunity appearing in Equation (5), mainly as the result of non-simultaneous trading, transaction costs and a liquidity shortage, factors that impede arbitrage activity as stated. Chan et al. (2008) defined the deviation from the LOOP in terms of Equation (5), as follows:

(5a) $$prem = R^{LM} - R^{US} - \Delta X$$

In a situation where prem = 0, there is no motivation for arbitrage transactions because there is no deviation from the Law of One Price. However, if prem > 0 at a certain time, then the return in the local market (R^{LM}) is greater than that in the foreign market (R^{US}), and the opposite if prem < 0. In that situation, arbitrage players can close the gap between the two markets in which the international dual stock is trading (that is, the gaps in excess of bid/ask spreads). In view of the existence of deviations from the Law of One Price, Chan et al. (2008) estimated the size of these deviations in the short term by means of the following regression:

[3] The assumption is that from the viewpoint of both the local and the foreign investor, there are no taxation differences between investment in the local market and investment in the global market. This is a reasonable assumption in view of personal taxation. Such taxation is predominant in advanced economies and in recent years came into effect in Israel as well. Even if taxation differences between the markets do exist, this should not have any material effect on the results since the variables included in the regressions are short-term rates of return (monthly), while the taxation differences are constant in the short term.

[4] This can be seen as follows: A combination of (2) $\Delta S^{LM} - \Delta X = \Delta S^{US}$ and (4) gives $R_F^{LM} = \Delta S^{US} = R_F^{LM}$. Similarly, (2) $\Delta S^{US} + \Delta X = \Delta S^{LM}$ and (3) gives $R_L^{US} = \Delta S^{LM} = R_L^{LM}$. A combination of the two sub-equations and their repositioning in (2) therefore gives $R_L^{LM} - R_F^{LM} = \Delta X$ and $R_L^{US} - R_F^{US} = \Delta X$.

(6) $prem_t = \alpha_0 + \alpha_1 L_t^{LM} + \alpha_2 L_t^{US} + \nu_t$

where L^{US} and L^{LM} represent liquidity indices in the global market and in the local market respectively, and ν is the error term. Equation (6) connects between the LOOP deviation (the explained variable) and variables that are likely to reflect such a situation. In particular, the liquidity indices L^{US} and L^{LM} , which in certain cases reflect inability to conduct arbitrage due to lack of liquidity, are likely to explain the existence of a premium different from zero, meaning a situation of market frictions. In a study of dual-listed stocks from 23 countries, Chan, et al., did indeed find that the average monthly premiums were significantly different from 0.

d. Effect of the exchange rate and LOOP deviation on the rate of return of dual-listed stocks

In view of the deviation from the Law of One Price, an alternative to accepted practice needs to be formulated. In order to do this, we will start by considering a non-dual-listed stock. A number of studies have attempted to estimate the extent to which exchange-rate risk affects the rate of return of a single stock that is not necessarily dual listed. For example, Cheng et al. (2010) estimated the effect of the exchange rate on the rates of return of 50 stocks in the Taiwanese economy, which is a small open economy, and found a significant simultaneous effect and a lesser effect with a lag of up to 4 periods. The regression that was run, which reflects an expanded market model for the exchange rate, was as follows:

(7) $$R_t = \alpha + \beta R_{mt} + \lambda \Delta X_t + \sum_{k=1}^{K} \phi_k \Delta X_{t-k} + \varepsilon_t$$

where R_t is the stock rate of return, R_{mt} is the local market rate of return, $\sum_{k=1}^{K} \phi_k \Delta X_{t-k}$ reflects the product of the changes in the exchange rate with a lag of up to K periods and the vector of the coefficients ϕ.

The equation distinguishes between a simultaneous effect of the exchange rate on the rate of return (λ) and a lagged effect that is not related to arbitrage (ϕ). Cheng et al. (2010) assessed that the coefficients' vector would be found to be positive for export companies (a depreciation of the local currency against the dollar improves their profitability) and negative for import companies. The addition of the market portfolio rate of return to the regression is intended to prevent bias in the coefficients resulting from the leaving out of omitted variables.

We will see below how it is possible to integrate between this model, which does not refer to the dual-listing of the stock, and the premium that was found in the study of Chan et al. (2008), which reflects LOOP deviations in dual-listed stocks. First, we will position the premium as defined in Equation (5a) on the left-hand side of the regression in (6), and we will solve the equation for the simultaneous change in the exchange rate as follows:

(8) $$\Delta X_t = R_t^{LM} - R_t^{US} - (\alpha_0 + \alpha_1 L_t^{LM} + \alpha_2 L_t^{US} + \nu_t)$$

where R_t^{LM} is the rate of return on the dual-listed stock in the local market and R_t^{US} is the rate of return of the dual-listed stock in the global market. We will now position ΔX_t in Equation (7), once for the local market and once for the global market, and we will position a single coefficient for the cumulative changes in the exchange rate (simultaneous with a lag) rather than the coefficients' vector:

(8a) $$R_t^{LM} = \beta_0 + \beta_1 R_{mt}^{LM} + \beta_2[R_t^{LM} - R_t^{US} - (\alpha_0 + \alpha_1 L_t^{LM} + \alpha_2 L_t^{US} + \nu_t)] + \beta_3 \sum_{k=0}^{K} \Delta X_{t-k} + \varepsilon_t^{LM} =>$$

$$R_t^{LM} = \delta_0 + \delta_1 R_{mt}^{LM} - \delta_2 L_t^{LM} - \delta_3 L_t^{US} + \delta_4 \sum_{k=0}^{K} \Delta X_{t-k} - \delta_5 R_t^{US} + \delta_t$$

Where, R_{mt}^{LM} is the local market's rate of return (the Tel Aviv 100 Index), ε_t^{LM} is the error term in the local market equation, and the coefficients after substituting are:

$$\delta_0 = \frac{\beta_0 - \beta_2\alpha_0}{1-\beta_2}; \delta_1 = \frac{\beta_1}{1-\beta_2}; \delta_2 = \frac{\beta_2\alpha_1}{1-\beta_2}; \delta_3 = \frac{\beta_2\alpha_2}{1-\beta_2}; \delta_4 = \frac{\beta_3}{1-\beta_2}; \delta_5 = \frac{\beta_2}{1-\beta_2}; \delta_t = \frac{\varepsilon_t^{LM} - \beta_2\nu_t}{1-\beta_2}$$

We note that Equation (8) expresses the simultaneous changes deriving from the arbitrage effect (relating to trading characteristics), but does not include simultaneous economic effects relating to the company's status as an exporter or an importer. Accordingly, the coefficient δ_4 represents the cumulative effect of the exchange rate (simultaneous and with a lag) on the stock rate of return in the local market. This is in addition to the simultaneous effect of the exchange rate relating to the arbitrage effect—ΔX_t—from Equation (8) above. Similarly, we solve the equation for the stock rate of return in the global market as follows:

(8b) $$R_t^{US} = \chi_0 + \chi_1 R_{mt}^{US} - \chi_2[R_t^{LM} - R_t^{US} - (\alpha_0 + \alpha_1 L_t^{LM} + \alpha_2 L_t^{US} + \nu_t)] - \chi_3 \sum_{k=0}^{K} \Delta X_{t-k} + \varepsilon_t^{US} =>$$

$$R_t^{US} = \theta_0 + \theta_1 R_{mt}^{US} + \theta_2 L_t^{LM} + \theta_3 L_t^{US} - \theta_4 \sum_{k=0}^{K} \Delta X_{t-k} - \theta_5 R_t^{LM} + \theta_t$$

Where, R_{mt}^{US} is the rate of return of the global market (the NASDAQ Index), ε_t^{US} is the error term in the global market equation, and the coefficients after substituting are:

$$\theta_0 = \frac{\chi_0 + \chi_2\alpha_0}{1-\chi_2}; \theta_1 = \frac{\chi_1}{1-\chi_2}; \theta_2 = \frac{\chi_2\alpha_1}{1-\chi_2}; \theta_3 = \frac{\chi_2\alpha_2}{1-\chi_2}; \theta_4 = \frac{\chi_3}{1-\chi_2}; \theta_5 = \frac{\chi_2}{1-\chi_2}; \theta_t = \frac{\varepsilon_t^{US} + \chi_2\nu_t}{1-\chi_2}$$

When the arbitrage equation (the LOOP deviation) is positioned in the expanded market model, in the local market and in the global market, the following results are obtained, which are *a priori* expressed in Equations (8a) and (8b):

1. Instead of the simultaneous exchange rate—ΔX_t, a simultaneous relationship was obtained between the rates of return in the two markets in which the dual-listed stock is traded—R_t^{LM} and R_t^{US}. This means that that the two rates of return must be run as simultaneous equation systems since the rates of return are both exogenous and endogenous.

2. The liquidity indices (L^{US}, L^{LM}) affect the stock rate of return in both the local and the global market. This is the result of the model of Chan et al. (2008), who explained the

LOOP deviations by means of the liquidity indices in the two markets in which the dual-listed stock is traded.

3. The cumulative change in the exchange rate (economic risk) $\sum_{k=0}^{K} \Delta X_{t-k}$ affects the rate of return in both the markets in the same direction. (The rate of return is measured in the local market and in the global market in opposite directions.)

4. If there is no deviation from the Law of One Price (Δprem = 0), Equation (7) is obtained for each of the markets in which the dual-listed is traded. This equation is intended to estimate the effect of the exchange rate (simultaneous and with a lag) on the rate of return of any stock, and not just a dual-listed stock. In this case, it is not possible to identify the effect of the economic risks due to 'under-identification' by the equation system.

Notice that the identification in the structural equations system (8a) and (8b) is exact identification by order condition[5], meaning that is possible to take the equations in their reduced form and revert from them to structural equations. (Appendix B presents a description of the equations in their reduced form.)

e. Actual estimation of the structural equations

Like Kwon et al. (2005), we distinguish between economic risk and exchange rate risk but unlike them, we will estimate these two risks in a structural equations system, distinguishing between stocks of export companies and stocks of import companies.

The effect of economic risk is indirect, because in an efficient market it influences the return on investment via the company's earnings and stock prices. Stocks of exporters that do not hedge against exchange-rate risk will be positively (negatively) affected by a depreciation (appreciation) of the shekel, while importers' stocks will be negatively (positively) affected by a depreciation (appreciation) of the shekel. Accordingly, if a deviation from the Law of One Price affects rates of return in both stock markets differentially and simultaneously, economic risk will affect rates of return in both markets in the same direction and to the same extent, and also with a lag. In terms of Equations (8a) and (8b), economic risk is expressed by $\sum_{k=0}^{K} \Delta X_{t-k}$. It is possible to constrain the coefficients in the structural equations (8a) and (8b), so that $\chi_3 = \beta_3$. This is in order to estimate the economic risk acting in the same direction on the common rates of return of the stock in both stock markets.

Priestley and Odegaard (2007) claim that in order to improve the estimation (and prevent endogeneity), orthogonalization is necessary between the exchange rate, the local stock index and the global index (in which the ADR is traded). This is because these exogenous data are likely to be correlated. We will therefore orthogonalize between the NASDAQ Index, the Tel Aviv 100 Index and the exchange rate. This is because the Tel

[5] In order to obtain exact identification in the simultaneous system of two equations, each equation must contain a single exogenous variable that is not found in the other equation. The local market rate of return, R_{mt}^{LM} , from Equation (8a) is missing in Equation (8b), and the global market rate of return, R_{mt}^{US} , from Equation (8b) is missing in Equation (8a).

Aviv 100 Index and the shekel/dollar exchange rate are likely to be affected by each other and by the NASDAQ Index, but not the opposite, due to the fact that the NASDAQ Index is a significant exogenous variable among all the variables, meaning that it is not affected by the local market variables. The orthogonalization is obtained from running the following two equations:

(9a) $$R_{mt\_ort}^{LM} = R_{mt}^{LM} - (\hat{\gamma}_0 + \hat{\gamma}_1 R_{mt}^{US} + \hat{\gamma}_2 \Delta X_t)$$

(9b) $$\Delta X_{t\_ort} = \Delta X_t - (\hat{\delta}_0 + \hat{\delta}_1 R_{mt}^{US} + \hat{\delta}_2 R_{mt}^{LM})$$

On the basis of the coefficients of the correlation prevailing in the sample period, orthogonalization is necessary between the (exogenous) NASDAQ Index and the Tel Aviv 100 Index, and to a lesser extent between the NASDAQ Index and the shekel/dollar exchange rate. This is because in the sample period, the correlation coefficient between the NASDAQ rate of return and the Tel Aviv 100 rate of return amounted to 0.74 (robust at 0.99), the correlation coefficient between the NASDAQ and shekel/dollar exchange rate adjustments amounted to -0.27 (robust at 0.99), and the correlation coefficient between the Tel Aviv 100 rate of return and shekel/dollar exchange rate adjustments amounted to -0.31 (robust at 0.99). Following the orthogonalization, the correlation coefficient between the NASDAQ rate of return, the Tel Aviv 100 rate of return, and the exchange rate changes was zero, as is necessary.

On the basis of Equations (8a) and (8b), the NASDAQ Index and the orthogonal Tel Aviv 100 Index would be expected to have a positive effect on the stock rate of return, that (local and global) liquidity would have a negative effect on the local market and a positive effect on the global market, while the economic risk $\sum_{k=0}^{K} \Delta X_{t-k}$ would be related to the nature of the company—export or import.

A continual depreciation (appreciation) will improve the position of an export (import) company that does not protect itself by means of hedging instruments or internal offsets. In other words, we would expect to find that economic risk has a positive and uniform effect on rates of return in both markets in which a dual-listed exporter's stock is traded, and a negative and uniform effect in both markets in which a dual-listed importer's stock is traded.

Relative to the LOOP deviation, it is more difficult to estimate the economic effect which a cumulative change in the shekel/dollar exchange rate exerts on the rate of return (the economic risk calculated as the average of the last K months), since this effect reflects the sensitivity of net profit to the exchange rate and as a result, the sensitivity of the company's capital and stock price to the exchange rate. Moreover, this effect is likely to change over time (as the result of the hedging of exchange rate positions, for example) and is not immediate, due either to sticky prices, lags in information flow or to the time taken by the markets to assess that a depreciation or appreciation is not temporary.

Added to the stocks in the sample was a peer group that includes companies whose stocks are traded in Tel Aviv alone, and whose share of foreign trade is insignificant. The peer group is intended to examine the differences in the impact of economic risk on the rate of return of dual-listed exporters' stocks, on the rate of return of dual-listed importers' stocks, and on the rate of return of non-dual-listed stocks that are neither exporters nor importers. Under a null hypothesis therefore, economic risk has a positive effect on the stocks of export companies, a negative effect on importers and has no effect on the stocks of the peer group.

4. DESCRIPTION OF THE DATA

The data in this study include the shekel/dollar exchange rate, and the prices of stocks which trade on both Tel Aviv and NASDAQ (from Bloomberg) adjusted for dividends and other benefits for the period 1/2004–12/2011 (96 monthly observations). In order to reduce the effect of non-simultaneous trading, included in the sample were closing data on stock prices in Tel Aviv and the exchange rate, and opening data on stock prices on NASDAQ on Monday through Thursday.[6] Based on opening and closing prices, the daily rates of return on the stocks in both stock markets were calculated, as were daily changes in the exchange rate on Monday through Thursday. Monthly rates of return and rates of change were then calculated on the basis of the results obtained. A monthly data frequency was selected since at this frequency non-simultaneous trading has little effect on the results (see also Footnote 6), and because economic risk affects stock rates of return with a lag. This lag is attributed partly to the time which it takes for the equity market to internalize the fact that a particular depreciation/appreciation is not temporary, and is therefore of economic significance for the company.

Export and import data for the companies in the sample were taken from the transaction system managed by the Information and Statistics Department at the Bank of Israel. Of the 14 companies included in the sample, 10 were denoted as exporters and 4 as importers/manufacturers whose activity is primarily in Israel. The nature of the company—exporter or importer—was determined by the ratio between net exports/imports and total trade, that is, (exports–imports)/(exports + imports) over the sample period.

Dual-listed stocks were classified into two groups: export companies (the sales of whose products abroad is significantly greater than their sales volume in Israel), and importers/manufacturers whose activity is centered in Israel (the sales of whose products in Israel is significantly greater than their sales volume abroad). A ratio close to 1 is indicative of an export company while a ratio close to -1 is indicative of an import company. Selected in the peer group were 10 non-dual-listed companies that are traded in Tel Aviv alone and without any major import/export activity. Table 1 presents data and basic statistics on the companies contained in the sample.

The table presents a list of companies that are diverse from the aspects of balance sheet size, equity capital and earnings per share. Panel A represents the dual-listed stocks of 10

[6] Despite this, there were periods in which closing time in Tel Aviv differed from opening time on NASDAQ, whether due to administrative decisions by the stock exchanges or because of the introduction of summer time and winter time on different dates. Since the data are monthly data, non-simultaneous trading has a very limited effect. (See the discussion in Chan et al., 2008, on the problem of lack of simultaneity and its implications for differing data frequency.)

leading exporters and 4 importers/manufacturers (below the line in the table). Since the balance sheet, equity capital, net earnings and trading volume of these companies differ, they can be regarded as companies representative of the population of dual-listed companies.[7] In most cases, the (exports – imports)/(exports + imports) ratio was positive and greater than 0.5 (exporters) or negative and less than -0.5 (importers). This is because a company does not usually change the nature of its activity from exporter to importer and vice versa. An exception is Ituran, which began intensive international activity only at the end of the sample period. At Ituran, the ratio in question amounted to -0.02.

Table 1
Data and basic statistics on a number of dual-listed companies and the peer group, 2004–2011

Company	Ticker	Total balance sheet NIS million (2011)	Shareholders' equity NIS million (2011)	Net profit NIS million (2011)	% of trading volume in Israel (percent) (2004–11)	(Exports – imports)/ (Exports + imports) (2004–11)	Nature of the company (2004–11)
A. Dual-listed companies							
AudioCodes	AUDC	736	405	27	8	0.55	Exporter
Elbit Systems	ESLT	14,216	3,433	345	66	0.83	Exporter
Given Imaging	GIVN	949	755	46	7	0.65	Exporter
Tower	TSEM	3,275	668	-71	42	0.26	Exporter
Teva	TEVA	191,593	84,807	10,542	3	0.47	Exporter
Nice Systems	NICE	6,044	4,427	219	15	0.82	Exporter
Mellanox	MLNX	2,025	1,690	38	4	0.65	Exporter
Radvision	RVSN	525	391	-89	4	0.61	Exporter
Retalix	RTLX	1,269	953	52	46	0.90	Exporter
Shamir Optics	SHMR	618	373	56	13	0.33	Exporter
Ituran	ITRN	602	387	81	25	-0.02	Importer
Hadera Paper	HAP	2,650	802	-117	62	-0.93	Importer
Cellcom	CEL	8,557	183	824	22	-0.50	Importer
Partner	PTNR	7,087	425	443	44	-0.80	Importer
B. Peer group—non-dual-listed, traded in local stock market and without significant exchange-rate exposure							
Avner	AVNER	2,361	951	259	100	NA	Local
Alrov	ALROV	9,887	2,084	-39	100	NA	Local
Granit	GRANI	5,170	760	30	100	NA	Local
DS Apex	DS_AP	18,408	458	72	100	NA	Local
Harel	HAREL	54,925	3,525	218	100	NA	Local
Isramco	ISRAM	2,431	1,248	-51	100	NA	Local
Migdal	MGDL	86,099	4,538	296	100	NA	Local
Menora	MMHD	31,982	2,200	38	100	NA	Local
Phoenix	PHOEN	64,385	2,551	54	100	NA	Local
Shikun & Binui	SHIKU	9,607	865	413	100	NA	Local

The stocks of the dual-listed companies below the line in Panel A are stocks of companies whose activity is centered in Israel and their currency exposure is therefore to a depreciation of the shekel/dollar exchange rate. The peer group in Panel B contains companies whose stocks are traded on the Tel Aviv Stock Exchange alone.

[7] Since the overwhelming majority of the 60 dual-listed companies are exporters, it will not be necessary to add to the companies presented in the table. In contrast, the sample contains all the import/manufacturing companies whose stocks are dual-listed and have a minimal tradability.

As the table indicates, exporters' and importers' cumulative rate of return was quite low. Relative trading volume (the third column from the right) reveals a distribution that is not dependent on whether the company is an exporter or importer. Accordingly, most trading in the stocks of exporter Elbit Systems and the Hadera Paper was conducted in Tel Aviv (66 percent and 62 percent, respectively), while the majority of trading in the stocks of exporter Teva and importer Cellcom was conducted in the US (3 percent and 22 percent, respectively). As we will see later, trading volumes, which represent liquidity indices in both the markets in which the dual-listed stock is traded, reflect the deviation from the Law of One Price.

Panel B in Table 1 presents the peer group. This contains companies whose stocks are traded only on the TASE and whose percentage of foreign trade is insignificant. These companies are presented to allow the examination of the effect of a cumulative change in the exchange rate (economic risk) on the rates of return on their stocks and to compare it to the effect on exporters' and importers' rate of return.

As noted in the literature review, a dual-listed company is traded in two markets and the rates of return on its stocks in each of them are not necessarily identical. This results from a deviation from the Law of One Price. Table 2 presents basic statistics on rates of return and exchange-rate risk premium (prem) as defined in Equation (5a).[8]

The table indicates that the rates of return of exporters' stocks are greater than those of importers' in both markets. This result reflects the fact that many exporters are high tech companies (with high technological intensity) and are notable for a relatively high risk and high rate of return. Importers, in contrast, are partly consumer companies (Cellcom and Hadera Paper, for example), are of lower technological intensity and so is their expected risk and rate of return.

[8] Of course this is not the standard exchange rate risk premium as defined in the FX literature but a deviation from the LOOP.

Table 2

Basic statistics on the dual-listed stock: NASDAQ rates of return compared with Tel Aviv and exchange rate risk premium, 2001/2004–2012/2011

		Traded on NASDAQ (R^{US})		Traded in local market (R^{LM})	
Company	Ticker	Average (percent)	Standard Deviation (percent)	Average (percent)	Standard Deviation (percent)
Dual-listed stocks					
A. Rate of return					
AudioCodes	AUDC	-0.016	0.88	-0.004	0.78
Elbit Systems	ESLT	0.118	0.49	0.084	0.36*
Given Imaging	GIVN	0.006	0.77	0.003	0.71
Tower	TSEM	0.023	1.35	-0.048	1.10
Teva	TEVA	0.023	0.34	0.050	0.37
Nice Systems	NICE	0.080	0.59	0.114	0.46
Mellanox	MLNX	0.142	0.86	0.073	0.67
Radvision	RVSN	-0.001	0.75	-0.029	0.75
Retalix	RTLX	0.073	0.74	-0.001	0.51
Shamir Optics	SHMR	0.124	0.81	-0.085	0.61
Ituran	ITRN	-0.022	0.77	0.051	0.53
Hadera Paper	HAP	0.052	1.66	0.003	0.51*
Cellcom	CEL	-0.012	0.55	-0.018	0.42
Partner	PTNR	0.003	0.49	0.020	0.43
Average exporters		0.057	0.76	0.016	0.63
Average importers		0.039	0.87	0.014	0.47

Company	Ticker	Average	Standard Deviation	Minimum	Maximum	Number of observations
B. Exchange rate premium (prem)						
AudioCodes	AUDC	0.020	0.44	-1.42	1.04	96
Elbit Systems	ESLT	-0.027	0.34	-1.05	0.84	96
Given Imaging	GIVN	0.035	0.41	-1.01	1.59	94
Tower	TSEM	-0.062	0.88	-2.45	4.90	96
Teva	TEVA	0.035	0.27	-0.49	1.11	96
Nice Systems	NICE	0.042	0.31	-0.76	1.00	96
Mellanox	MLNX	-0.056	0.51	-1.33	1.59	54
Radvision	RVSN	-0.020	0.41	-0.92	1.12	96
Retalix	RTLX	-0.065	0.54	-2.06	1.77	96
Shamir Optics	SHMR	-0.18*	0.56	-1.50	1.25	74
Ituran	ITRN	0.059	0.45	-1.01	1.79	76
Hadera Paper	HAP	-0.033	1.51	-2.71	12.23	93
Cellcom	CEL	0.023	0.34	-0.47	1.44	54
Partner	PTNR	0.024	0.34	-0.67	1.16	96
Average exporters		-0.011	0.47			89
Average importers		0.018	0.66			80

The dual-listed stocks above the line are of exporters, and those below the line belong to companies whose activity is centered in Israel and whose natural exposure is to a depreciation of the shekel/dollar exchange rate (importers). The observations are based on a monthly average of daily rates of return on days when simultaneous trading occurs. The risk premium was calculated as defined in Equation (5a).

* Represents a confidence level of 0.95 or more (for rejection of the null hypothesis) in tests for equality between the average and the volatility of the rates of return in both stock markets. The equality of means test is based on a Welch F-test (permitting different standards deviation between the two series), and equality of standard deviation is tested by means of a Levene test. The tests show that it is not possible to reject the hypotheses that the averages are equal, compared with the standard deviations, which were found to differ in certain cases. In a test on the exchange-rate premium (prem), it was not possible to reject the hypothesis that the average premium equals 0 at a confidence level of 0.95, except in the case of Shamir.

During the sample period, the average return of the stocks on the NASDAQ was higher than the average rate of return in Tel Aviv. The daily rate of return of exporters on the NASDAQ amounted to 0.057 percent compared with 0.016 percent in Tel Aviv (an annual rate of return of 14.3 percent and 3.9 percent, respectively), and importers' daily rate of return amounted to 0.039 percent on the NASDAQ compared with 0.014 percent in Tel Aviv (an annual rate of return of 9.9 percent and 3.5 percent respectively). However, with a Welch F-test of equality of means, no stock was found with different rate of return at a confidence level of 0.95, meaning that there was no significant difference between the rates of return. Neither were significant differences found in a Levene test of the variance gaps between the two markets (at a confidence level of 95 percent), with the exception of the stock of exporter Elbit Systems and the stock of importer Hadera Paper. Differences between the rate of return distribution in Tel Aviv and on the NASDAQ reflect a deviation from the Law of One Price and an exchange-rate risk premium different from zero. Panel B in the table presents the risk premium as defined in Equation (5a). As can be seen, the average risk premium of export companies was negative at -0.011 percent, compared with a positive premium of 0.018 percent among importers. As stated, a negative premium in a particular month implies that the rate of return on NASDAQ was higher than that in Tel Aviv and a positive premium implies the opposite. But such a conclusion should not be drawn for the average risk premium for the entire period, because this average is determined partially according to the changes in the exchange rate. Among all the exchange rate risk premiums, only that of exporter Shamir was different from zero at a confidence level of 0.95. It should be noted that in the comparison with the exchange-rate risk premiums obtained in the study of Chan et al. (2008), the LOOP deviation in the dual-listed stocks in the sample was small. The average risk premium was 7.09 percent for the six dual-listed stocks, for exporters it was -2.7 percent, and for importers, 4.6 percent. The difference between the results may be related to the following two facts: (1) The local equity market has become increasingly efficient over the years, due *inter alia* to algo trading, machine trading and foreign investors' entry into the local market (see Hauser et al., 2012); (2) The number of stocks in the sample was more than double that of Chan et al., while most of them are high-tech companies and are therefore notable for a relatively large number of foreign investors. These facts may also explain why the average exchange-rate risk premium of exporters (at absolute value) is less than that of importers whose main tradability is in Israel.

5. RESULTS OF THE ESTIMATION

a. Extraction of the economic risk

The literature on dual-listed stocks and especially that attempting to determine which of the two stock markets on which a stock is traded influences it more, usually ignores the differences between the prices of the stock in the two markets. The accepted practice is to assume that the premium is equal to zero (with no arbitrage opportunity), meaning that there is no deviation from the Law of One Price, and to run the expanded market model

(Equation 7) (see, for example, Hauser et al., 2012; Cheng et al., 2010; Patnaik and Shah 2010). Table 3 illustrates the problem involved in ignoring these differences. The table presents two OLS regressions on the basis of the expanded market model, but instead of a simultaneous exchange rate they contain the cumulative change in the exchange rate:

$$R_{it} = \alpha_i + \chi_i R_{mt}^{US} + \delta_i R_{mt}^{LM} + \phi_i \sum_{k=0}^{K} \Delta X_{t-k} + \varepsilon_i \quad (10)$$

where R_{it} represents the rate of return of stock i in month t in each of the two markets separately, R_m^{US} and R_m^{LM} is the American and local market rate of return, respectively, $\sum_{k=0}^{K} \Delta X_{t-k}$ reflects the cumulative change in the exchange rate, K=3, and ε is the error term. The upper part of the table presents the results of the regression in which the explained variable is the rate of return on the dual-listed stock when it is traded on the NASDAQ, while the middle part presents the results of the regression in which the explained variable is the rate of return on that stock when it is traded in Tel Aviv.

As can be seen from the table, both the regressions—that in Panel A and that in Panel B—contain exactly the same explanatory variables, but yield completely different results. Nearly all the stocks were positively and robustly (at a confidence level of 0.95) affected by the NASDAQ Index, or by the Tel Aviv 100 Index after orthogonalization, or by both. In some cases, however, economic risk had a different effect on the rates of return in the two markets. With the stocks of Elbit Systems, Given Imaging, Tower and Ituran for example, the coefficients of economic risk were negative in the NASDAQ and positive in Tel Aviv. In some cases, the coefficients in both markets had the same sign, although in one of the markets the coefficient was significant and in the other it was not (Teva and Retalix). In such circumstances—when the coefficients in the two markets do not have the same sign, or when one of them is significant and the other is insignificant—it is difficult to ascertain the impact of economic risk.

Table 3

Results of the expanded market model regression(OLS): Rates of return of dual-listed stocks, NASDAQ compared with Tel Aviv, 2001/2004–2012/2011

		Explanatory variables					
Company name	Ticker	α	χ	δ	Φ	Adj. R^2	D.W.
A. Dual-listed stocks on the NASDAQ							
AudioCodes	AUDC	0.000	1.36^{**}	0.51^{*}	-1.19	0.30	1.99
Elbit Systems	ESLT	0.00^{**}	0.56^{**}	0.245	-0.66	0.14	1.98
Given Imaging	GIVN	0.000	1.33^{**}	0.238	-0.07	0.35	1.94
Tower	TSEM	0.000	0.754	1.38^{**}	-2.24	0.15	1.93
Teva	TEVA	0.000	0.37^{**}	0.23^{*}	0.16	0.17	1.99
Nice Systems	NICE	0.00^{**}	1.02^{**}	0.47^{**}	-0.08	0.47	2.02
Mellanox	MLNX	0.00^{**}	1.37^{**}	0.51^{*}	-0.54	0.47	1.94
Radvision	RVSN	0.000	0.360	0.52^{*}	2.22^{*}	0.12	1.91
Retalix	RTLX	0.001	1.01^{**}	0.49^{*}	-0.60	0.22	2.03
Shamir Optics	SHMR	0.001	0.99^{**}	0.340	-0.35	0.24	2.15
Ituran	ITRN	0.000	1.16^{**}	0.65^{**}	-0.65	0.39	2.02
Hadera Paper	HAP	0.000	0.665	0.273	-2.37	-0.03	2.00
Cellcom	CEL	0.000	0.65^{**}	0.241	-1.22	0.20	1.97
Partner	PTNR	0.000	0.64^{**}	0.40^{**}	-0.70	0.23	1.96
B. Dual-listed stocks in the local market (R^{LM})							
AudioCodes	AUDC	0.000	0.88^{**}	0.354	-0.671	0.17	1.96
Elbit Systems	ESLT	0.00^{**}	0.203	0.215	0.321	0.06	2.02
Given Imaging	GIVN	0.000	1.08^{**}	0.163	0.313	0.25	1.98
Tower	TSEM	0.000	1.14^{**}	1.66^{**}	0.777	0.35	2.02
Teva	TEVA	0.001	-0.075	0.127	1.08^{*}	0.02	2.00
Nice Systems	NICE	0.00^{**}	0.50^{**}	0.43^{**}	0.587	0.23	2.01
Mellanox	MLNX	0.001	0.74^{**}	0.185	0.122	0.17	1.95
Radvision	RVSN	0.000	0.085	0.347	3.27^{**}	0.12	1.94
Retalix	RTLX	0.000	0.63^{**}	0.37^{*}	1.29^{*}	0.27	1.97
Shamir Optics	SHMR	-0.001	0.85^{**}	0.55^{*}	0.267	0.33	1.92
Ituran	ITRN	0.001	0.51^{**}	0.55^{**}	0.307	0.24	2.01
Hadera Paper	HAP	0.000	0.59^{**}	0.75^{**}	-0.795	0.31	1.99
Cellcom	CEL	0.000	0.208	0.169	-0.400	-0.04	1.92
Partner	PTNR	0.000	0.30^{*}	0.51^{**}	-0.303	0.16	1.98
C. Are not dual-listed stocks and are traded in the local market (and without significant exchange-rate exposure)							
Avner	AVNER	0.00^{*}	0.30^{*}	0.273	0.524	0.09	1.99
Alrov	ALROV	0.001	1.04^{**}	1.86^{**}	0.981	0.34	1.91
Granit	GRANI	0.000	0.51^{**}	0.37^{*}	-0.906	0.12	2.01
DS Apex	DS_AP	0.000	1.01^{**}	0.76^{**}	-0.459	0.47	2.00
Harel	HAREL	0.000	0.62^{**}	0.87^{**}	-0.329	0.50	1.82
Isramco	ISRAM	0.001	0.167	0.60^{**}	0.892	0.09	2.04
Migdal	MEGDA	0.000	0.61^{**}	0.82^{**}	0.019	0.42	2.09
Menora	MENOR	0.000	0.38^{**}	0.68^{**}	0.612	0.19	1.95
Phoenix	PHOEN	0.000	1.42^{**}	1.18^{**}	-0.704	0.50	2.02
Shikun & Binui	SHIKU	0.000	0.49^{**}	0.49^{**}	-0.050	0.16	1.95

The stocks above the line are of exporters, and those below the line belong to companies whose activity is centered in Israel and whose natural exposure is to a depreciation of the shekel/dollar exchange rate (importers). In each of the regressions, the expanded market model (plus the counterpart equity market index) is assessed according equation (10) with K = 3 and both R^{LM}_{mt} and ΔX are after orthogonalization. Added to the regression were two AR variables for serial correlation (not represented in the table). The cumulative effect (simultaneous and with a lag) of the exchange rate on the rate of return differs markedly between the two markets in which the dual-listed stock is traded, and differs in significance and in certain cases, in the direction of the effect (Given Imaging, for example). With the importers' stocks, the direction of the effect is usually negative in both markets although not significant. As expected, with stocks that are not dual-listed and are not significantly exposed to the exchange rate, the exchange rate was not found to affect the rate of return of any of the stocks.

* Represents a confidence level of 0.95. ** Represents a confidence level of 0.99.

Like the stocks of the companies in the sample, the NASDAQ Index and the Tel Aviv 100 Index after orthogonalization had positive and significant effects on the rates of return of the stocks in the peer group (Panel C). As expected, economic risk had no significant effect on any of the companies in the peer group. Among the export and import companies in the sample, however, there were those on which the exchange rate had no significant effect, and as expected by Equations (8a) and (8b) the rates of return in both markets must be run as a simultaneous equations system rather than as two separate equations.

In view of the differences—which are significant to the extent of changing the sign—between the exchange rate coefficients in the two markets, the effect of economic risk must be estimated by taking into account the common factor of both the rates of return and the deviations from LOOP (Equations 8a and 8b). This study proposes two alternatives for estimating the economic risk of the exchange rate.

The first alternative

We run first the structural equations (8a) and (8b) as a Generalized Method of Moments (GMM) equations system under the constraint of a single coefficient for economic risk for both the equations. We then create a representative weighted rate of return of the two stock markets by means of Principal Component Analysis (PCA). We will run the main component created in this procedure (the largest Eigen value, which contributed the most to explaining the variability) in place of the two rates of return. The results of running the first alternative appear in Table 4.

As compared to Table 3, each equation contains the rate of return of the dual-listed stock in the parallel market. In addition, the structural equations system takes into account the arbitrage effect (a deviation from the LOOP) by including two liquidity variables, L^{US} and L^{LM}, in the regressions in both the markets. The GMM procedure was run as a time series with a Heteroskedasticity Autocorrelation Consistent (HAC) Time Series Estimator and with a Bartlett kernel. The GMM procedure has an advantage over other procedures when the sampling of variables with errors is suspected, a phenomenon that exists with dual-listed stocks, especially when there is no simultaneous trading. As instrumental variables, all the variables were taken with a lag of a month.

Table 4

Results of the (GMM) structural equations regressions; rate of return of the stock on NASDAQ compared with Tel Aviv, 2001/2004–2012/2011

		Explanatory variables							
Company name	Ticker	θ_0	θ_1	θ_2	θ_3	ϕ	θ_5	Adj. R^2	D.W.
A. Traded on NASDAQ (R^{US})									
AudioCodes	AUDC	0.000	0.57**	0.00*	0.033	-0.059	0.89**	0.76	1.93
Elbit Systems	ESLT	0.000	0.37**	-0.029	0.039	-0.136	0.89**	0.51	1.95
Given Imaging	GIVN	-0.001	0.28**	0.00*	0.16*	0.030	0.94**	0.67	2.02
Tower	TSEM	-0.001	-0.28**	0.01*	-0.005	-0.227	0.96**	0.56	1.86
Teva	TEVA	0.00*	0.42**	0.00**	0.01**	0.39**	0.61**	0.50	2.06
Nice Systems	NICE	-0.001	0.73**	0.00*	-0.006	-0.075	0.79**	0.73	2.03
Mellanox	MLNX	0.001	0.78**	0.000	-0.009	0.043	0.80**	0.72	2.06
Radvision	RVSN	-0.001	0.38**	0.002	0.21**	0.39**	0.84**	0.68	2.06
Retalix	RTLX	-0.001	0.65**	0.010	0.082	-0.266	0.68**	0.36	2.09
Shamir Optics	SHMR	0.00**	0.37**	-0.10**	1.08**	-0.307	0.75**	0.49	2.36
Ituran	ITRN	0.00**	0.67**	-0.010	0.24**	-0.076	1.04**	0.59	1.92
Hadera Paper	HAP	-0.001	0.034	2.18**	-0.995	-1.15**	1.34**	0.11	2.03
Cellcom	CEL	-0.001	0.56**	0.002	0.001	-0.29**	0.86**	0.52	1.94
Partner	PTNR	0.00**	0.43**	-0.002	0.02**	-0.19**	0.76**	0.61	1.83
		Explanatory variables							
Company name	Ticker	δ_0	δ_1	δ_2	δ_3	ϕ	δ_5	Adj. R^2	D.W.
B. Traded in the local market (R^{LM})									
AudioCodes	AUDC	0.000	-0.10*	-0.002	0.027	-0.059	0.79**	0.70	1.87
Elbit Systems	ESLT	0.000	0.11*	-0.002	-0.005	-0.136	0.52**	0.44	2.03
Given Imaging	GIVN	0.000	0.013	0.00*	0.091	0.030	0.90**	0.57	1.94
Tower	TSEM	-0.001	0.98**	0.01*	-0.01**	-0.227	0.53**	0.62	1.95
Teva	TEVA	0.000	0.024	0.000	0.000	0.39**	0.71**	0.34	1.99
Nice Systems	NICE	0.000	0.17**	-0.001	-0.008	-0.075	0.59**	0.59	1.96
Mellanox	MLNX	0.00**	-0.30**	0.01**	0.014	0.043	0.72**	0.57	2.10
Radvision	RVSN	0.001	-0.001	-0.001	0.27**	0.39**	0.83**	0.70	2.03
Retalix	RTLX	0.000	0.18*	0.09**	-0.13**	-0.266	0.35**	0.32	2.06
Shamir Optics	SHMR	0.00**	0.26**	-0.04*	-0.010	-0.307	0.50**	0.49	1.93
Ituran	ITRN	0.00**	0.17**	-0.01*	0.18**	-0.076	0.61**	0.43	1.95
Hadera Paper	HAP	0.000	0.78**	1.054	-1.20**	-1.15**	0.12**	0.33	2.02
Cellcom	CEL	0.00**	-0.012	0.02**	-0.03**	-0.29**	0.53**	0.44	2.10
Partner	PTNR	0.000	0.26**	0.000	-0.001	-0.19**	0.61**	0.56	1.93

The system that was run contains the structural equations (8a) and (8b):

$$R_t^{US} = \theta_0 + \theta_1 R_{mt}^{US} + \theta_2 L_t^{LM} + \theta_3 L_t^{US} + \phi \sum_{k=0}^{K} \Delta X_{t-k} - \theta_5 R_t^{LM} + \theta_t \quad \text{(8a)}$$

$$R_t^{LM} = \delta_0 + \delta_1 R_{mt}^{LM} - \delta_2 L_t^{LM} - \delta_3 L_t^{US} + \phi \sum_{k=0}^{K} \Delta X_{t-k} - \delta_5 R_t^{US} + \delta_t \quad \text{(8b)}$$

where R_t is the stock rate of return, R^{US}_{mt} is the NASDAQ Index rate of return, R^{LM}_{mt} is the Tel Aviv 100 index rate of return after orthogonalization, ΔX is the change in the shekel/dollar exchange rate after orthogonalization, K=3, and ε represents the unexplained factor in the regression. Two AR variables were included in the regressions to correct for autocorrelation (not represented in the table). L^{US}_t and L^{LM}_t are liquidity indices (trading volume) for the American market and the Israeli market, respectively. The economic risk coefficients in both equations had to be equal to each other–ϕ. The cumulative effect of the exchange rate (economic risk) on the rate of return of exporters' stocks differs considerably from its effect on importers' stocks.

With importers' stocks, the direction of the effect is negative and significant (except for Ituran, which is not a typical importer). Exporters' stocks are heterogeneous in the direction of the effect and in the case of two stocks (Teva and Radvision), the effect is positive and significant, as expected.

* Represents a confidence level of 0.95. ** Represents a confidence level of 0.99.

The table shows that all of the NASDAQ Index coefficients in Panel A were significant at a level of 0.99. The equation in Panel B also produced positive and significant results for many of the coefficients of the Tel Aviv 100 Index orthogonalized to the NASDAQ Index and the shekel/dollar exchange rate, which should reflect local phenomena. However, the robustness was lower than that of the NASDAQ coefficients, and in some cases (Mellanox) the sign was negative. The rate of return of the dual-listed stock in the other market (θ_5 and δ_5) was positive and robust at a 0.99 significance level in all cases. This finding is in line with the structural equations system (8a)–(8b), and is indicative of the importance of the estimation as an equations system. This compares with the evidence, whereby the positioning of the dual-listed stock in the counterpart market as an exogenous variable is ignored, resulting in simultaneous equations bias.

The two liquidity indices, L^{US} and L^{LM}, had opposite signs to each other in most cases, but were significant with only half of the stocks in the sample. Economic risk (ϕ), which had to be equal in both the structural equations, was found to be significant (at the 0.99 confidence level) in 5 out of the 14 dual-listed stocks in the sample. Out of these 5 cases, the coefficient was found to be positive for two exporters (Teva and Radvision) and negative for three importers (Hadera Paper, Cellcom and Partner). As noted, the fourth importer in the sample, Ituran, became an exporter during the sample period, and is therefore not perceived as a natural importer in the market, This is despite the fact that its economic risk coefficient was negative (-0.076). The economic risk coefficient for the other exporters was sometimes positive and sometimes negative, but in no case was it significant. This result is consistent with the hypothesis that exporters protect against exposure to economic risk in different ways (Bartram et al., 2010), is consistent with the findings of Priestley and Odegaard (2007), who show that the exchange rate has a different effect on export-oriented industries and import-oriented industries, and is consistent with Cheng et al. (2010), who reported that exposure to the Taiwanese (NTD/USD) exchange rate differs between exporters and importers.

A comparison of the effect of the exchange rate on the rates of return obtained on the basis of the structural equations system (Table 4) with the effect obtained for each market separately (Table 3) is likely to be indicative of the contribution of the estimation which was suggested and, in particular, of the (quantitative) economic risk.[9] The value of most of the economic risk coefficients in Table 4 (ϕ) generally ranges between the two values in Table 3 (ϕ)—the companies traded on the NASDAQ (Panel A) and the companies traded in the local stock market (Panel B). This applies particularly when the coefficient is found to be negative in one of the markets and positive in the other. For example, the economic risk coefficient of Tower in the structural equations system (Table 4) was -0.227, compared with an exchange rate coefficient of -2.24 in Panel A in Table 3, and a coefficient of 0.777 in Panel B in the same table. In cases where the exchange rate coefficients in both the panels in Table 3 had the same sign (either positive or negative), the economic risk

[9] The comparison between the economic risk coefficients is not precise, because the structural equations system represents a different model and statistical procedure from those run for each market separately. However, a general impression can be obtained from the differences between the model represented in Equation (10) and Table 3, and the system of structural equations that represents Equations (8a) and (8b) and Table 4.

coefficient in Table 4 had the same sign as well, although it is not necessarily found between the values of the two coefficients in Table 3. For example, the (significant) economic risk coefficient of Radvision in Table 4 amounted to 0.39, compared with a (significant) exchange-rate coefficient of 2.22 in Panel A in Table 3 and a (significant) coefficient of 3.27 in Panel B. It is actually in those cases where the exchange-rate coefficients in both stock markets have the same sign that the estimation of the economic risk coefficient within the framework of the Equations system (Table 4) has a more notably significant effect. This is because in most cases, the economic risk coefficient in Table 4 is not found between the two values of the exchange rate coefficients in Table 3.

The second alternative

The second alternative for estimating the effect of economic risk on the rate of return of dual-listed stocks involves the use of Principal Component Analysis (PCA) and the extraction of the principal component (the largest Eigen value, which contributes the most to explaining the variability) as representative of both rates of return. The change in the principal component is estimated as the explained (endogenous) variable within the framework of a panel with fixed effect. Since the principal component is orthogonal to both the rates of return, the arbitrage effect and the LOOP deviation (prem) are expressed by means of the liquidity indices, according to Equation (6). The common variables were thereby the rates of return of the stock indices on the NASDAQ and in Tel Aviv and the liquidity indices in both markets, while the specific variables for each stock were the intercept and the economic risk. In order to isolate the effect of a company being an exporter or an importer as well as to isolate a change during the period from the status of importer to exporter (the case of Ituran), a dummy variable was added to the regression, and it received the value of 1 in the case of an exporter and 0 in the case of an importer. This variable was fixed at all the companies except for Ituran, since the variable in it received the value of 0 at the beginning of the period (until 12/2009) and the value of 1 at the end of the period. This dummy variable was multiplied by the cumulative change in the exchange rate as a variable common to all the companies in the sample:

$$PC1_{it} = \alpha_i + \beta_1 R_{mt}^{US} + \beta_2 R_{mt}^{LM} + \chi_1 L_{it}^{US} + \chi_2 L_{it}^{LM} + \frac{\phi_i}{K+1}\sum_{k=0}^{K} \Delta X_{t-k} + \frac{\phi * dumE}{K+1}\sum_{k=0}^{K} \Delta X_{t-k} + \varepsilon_{it} \quad (11)$$

where $PC1_{it}$ is the change in the principal component of stock i in month t, α_i is the specific intercept for each dual-listed stock, ϕ_i is the economic risk coefficient of each dual-listed stock, ϕ is the common risk coefficient for all exporters/importers, dumE is the dummy variable for an export company, and L^{US} and L^{LM} are the two common liquidity indices for all the stocks in the two markets in which the stock is traded. Table 5 below presents the results of the run.

The table indicates the common effect which the explanatory variables exert on the main component of each stock in the sample (Panel A) and the unique effect of each stock (Panel B). The market variables—the NASDAQ Index rate of return and the orthogonal Tel

Aviv 100 Index rate of return—exerted a positive effect at a confidence level of 0.99. The local liquidity index, L^{LM} , and the NASDAQ liquidity index, L^{US} , affected the explained variable in opposite directions, at a confidence level of 0.99 and 0.95, respectively. As stated, these effects are simultaneous and are related to the LOOP deviation deriving from the lack of arbitrage opportunity.

When the dummy variable for export companies was multiplied by the cumulative change in the exchange rate, no significant result was produced. According to the null hypothesis, the economic risk should exert a positive and highly robust effect on the rate of return of exporters' dual-listed stocks, an effect opposite to its effect on importers' rate of return. The table (Panel B) shows that economic risk affected the rate of return of all importers negatively and at a confidence level of 99 percent, except for Ituran (which as stated changed from being an importer to an exporter during the sample period, and is therefore not a typical importer). Among exporters, however, not a single stock was found whose rate of return was affected by economic risk at a confidence level of 99 percent, nor at a confidence level of 90 percent either, while some of the coefficients were positive and some of them were negative.

Economic risk affects the representative rates of return that were obtained within the framework of the panel, and these effects are quite similar to those obtained within the framework of the estimation of the structural equations (Table 4). Accordingly, they support the conclusion that the importers group is negatively affected by a cumulative depreciation of the exchange rate, while no significant effect was found among the exporters group, which is heterogeneous. However, since the explained variable is not denominated in rate of return terms (it was created in a PCA procedure), the coefficients do not represent the exposure to economic risk like the structural equations in Table 4.

Table 5
Panel regression results of the component common to both rates of return (economic risk), calculated by PCA

		Coeff.	T-Stat.	Prob.
A. Common coefficients				
	β_1	0.258	9.90	0.00
	β_2	0.370	13.57	0.00
	χ_1	0.000	-2.25	0.02
	χ_2	0.002	3.07	0.00
	ϕ*dumE	-0.454	-0.37	0.71
	AR(1)	0.148	5.04	0.00
	Adj. R^2		0.25	
	D.W.		1.99	

		α_i		ϕ_i	
Company	Ticker	Coeff.	T-Stat.	Coeff.	T-Stat.
B. Specific cross section coefficients					
AudioCodes	AUDC	0.000	-0.67	0.142	0.11
Elbit Systems	ESLT	0.000	0.53	-0.558	-0.44
Given Imaging	GIVN	0.000	-0.78	0.088	0.07
Tower	TSEM	-0.001	**-3.22**	-0.028	-0.02
Teva	TEVA	0.002	2.02	0.373	0.29
Nice Systems	NICE	0.000	1.27	0.026	0.02
Mellanox	MLNX	0.001	1.64	-0.015	-0.01
Radvision	RVSN	0.000	-0.24	0.819	0.63
Retalix	RTLX	0.000	-0.45	0.656	0.51
Shamir Optics	SHMR	0.000	-0.50	-0.055	-0.04
Ituran	ITRN	0.000	0.35	0.080	0.10
Hadera Paper	HAP	0.000	-0.50	-1.780	**-3.47**
Cellcom	CEL	-0.001	-0.64	-2.128	**-3.06**
Partner	PTNR	0.000	-0.73	-1.468	**-5.37**

The stocks above the line belong to exporters, and those below the line belong to companies whose activity is centered in Israel and whose natural exposure is to a depreciation of the shekel/dollar exchange rate (importers). The panel regression results are according equation (11). The dummy variable for an exporter, dumE, received the value of 1 for export companies and 0 for exporters. Ituran received the value 0 until 12/2009 and the value 1 thereafter.
Significant correlation coefficients (robust at 0.99) in Panel B were highlighted in bold type.

b. Discussion

The effect of economic risk on exporters' rate of return differed completely from its effect on importers' rate of return, and was significant with respect to importers in all the models and the regressions that were run. The effect of economic risk on import companies was therefore found to be significantly negative, as expected, while the effect on export companies was ambiguous. In some cases a positive (and sometimes even significant) effect was observed, and in some cases a negative, but a significant effect was never observed. This phenomenon likely derives from the varying characteristics of export companies, such as: target markets (dollar, euro), the location of production (in Israel and/or abroad), the location of R&D (Israel and/or abroad), the economic industry (such as pharmaceuticals, electronic devices or software) and the level of competition in it, and even the base currency (shekel or dollar). For example, a large part of the production of the Teva pharmaceuticals company is located at subsidiaries abroad, development is mostly in Israel and the base currency is the dollar. Compared with the considerable heterogeneity among exporters, importers are companies whose base currency is the shekel, they are consumption companies and their activity is centered in Israel, in an environment where the level of competition during the sample period was not particularly high. It should be noted that since both arbitrage and economic risk affect rates of return at the capital market level only, these effects reflect investors' expectations regarding stock performance and their assessments regarding the company's exchange rate exposure, and not the exposure itself. This is also one of the reasons why economic risk is estimated on the basis of monthly data with a lag.

Under practices adopted by the Israeli Central Bureau of Statistics, the extent of the exchange-rate exposure of an investment in a dual-listed stock is calculated in the same way as it is calculated for a non-dual-listed stock.[10] For example, if the value of an Israeli resident's investment in dual-listed foreign stocks is V_t, where V_t is his position at time t, the exposure to the exchange rate is $1*V_t$. In view of the distinction made between the arbitrage effect and LOOP deviation, and the effect of economic risk, a dual-listed company's exchange-rate exposure can be calculated more accurately. The conclusion obtained from the proposed methodology is that exposure in dual-listed stocks, namely economic risk, should be calculated while neutralizing the arbitrage effect and the LOOP deviation because these could bias the coefficient in the regression. Accordingly, if the coefficient in the economic risk regression (ϕ) is taken (in the structural equations regression in Table 4) and multiplied by the position, the extent of the exposure of an investment in a dual-listed stock, ϕV_t, is obtained.[11] This result is not related to the identity of the investor (foreign resident or local resident) or to the identity of the stock market in which the investment is made (NASDAQ or Tel Aviv), because the risk is economic (acting on both rates of return in the same direction and at the same intensity).

c. Robustness checks

The above models and regressions were also tested for the nominal effective exchange rate of the shekel, which is calculated according to the weights of Israel's trade and includes the dollar, and according to the representative shekel/dollar exchange rate. (These data are published by the Bank of Israel). The results obtained were in the same directions but less

[10] Kadosh (2005) proposed a number of examinations for determining whether a company belongs to the local market or the global market, including sales abroad, location of the head office, location of R&D activity, and the currency of the financial statements. Instead of determining whether the company is local or global, this study compiles a quantitative index for the estimation of economic risk, and proposes to use it and thereby refer to the exposure at the total amount of the investment.

[11] It should be noted that since the coefficient was obtained from the changes in the exchange rate after orthogonalization, the coefficient should be converted in order to match the original values of the exchange rate.

significant, apparently because the shekel/dollar exchange rate is more volatile than the nominal effective exchange rate, and due to the fact that the shekel/dollar closing rate is not synchronized with the opening rates of the dual-listed stocks on the NASDAQ. In addition, the NASDAQ Index and the Tel Aviv 100 Index were replaced by the S&P 500 Index and the General Stock Index on the Tel Aviv Stock Exchange—in all cases, the results obtained were similar but less significant. In order to check the effect of data frequency, instead of monthly rates of return, weekly rates of return with the same lags were examined. The results regarding the effect of economic risk were less significant, supporting the hypothesis that the capital market needs time in order to decide that either depreciation or appreciation is not transitory. Concurrently, the effect of economic risk was examined in the model with monthly lags (from a month to six months) instead of a sum of the lags and a single coefficient. The results obtained were similar to those presented. Since the effect of the exchange rate (economic risk) is cumulative, a particular lag from a month to six months is of no interest. The stocks of other exporters were examined as well, and the picture obtained was similar to that presented in the tables. In order to examine the robustness of the results, all the regressions were run again for the second half of the sample period 1/2008–12/2012. The results obtained were similar to those obtained in the entire period, although the level of significance was lower among the import companies. It should be noted in this respect that Ituran's economic risk coefficient became positive (although not significant) in the structural equations (Table 4). As stated, this finding results from the fact that Ituran became an exporter in recent years. However, the two liquidity indices became insignificant. Finally, Priestley and Odegaard (2007) found that the exchange rate exerts non-linear effects on stocks' rate of return. In order to check this hypothesis on the rates of return of the stocks in the sample, like Priestley and Odegaard, I added to the regression the squares of the changes in the exchange rate. The results obtained were not clear-cut. In most cases, the coefficients of the squares of the changes in the exchange rate were not significant. In some cases positive coefficients were found and in other cases negative coefficients were found, regardless of whether the company was an exporter or an importer.

6. SUMMARY

The number of Israeli companies whose stocks are dual-listed—traded simultaneously on the Tel Aviv Stock Exchange and on another global stock market such as the NASDAQ—has increased greatly during recent years. Accordingly, and in order to examine the forces acting on the local foreign exchange market, it is important to estimate the precise exposure of holders of dual-listed stocks to the exchange rate. The estimation of the effect of the exchange rate on the return on investment in a dual-listed stock when it is traded in Tel Aviv could differ from the estimation when the stock is traded on the NASDAQ. This result stems from the fact that the exchange rate has a differential effect on the rates of return (the arbitrage effect and the deviation from the Law of One Price - LOOP). The arbitrage effect is simultaneous, and influences investment returns on the two stock markets differentially. In other words, as the result of arbitrage constraints, a change in the exchange rate (all other things being equal) should, partly or entirely, simultaneously add to the stock's rate of return on NASDAQ and/or simultaneously detract from the stock's rate of return in Tel Aviv. This effect is related to such factors as differences in trading terms between the local and the global stock markets (costs, spreads, etc.), investor preferences, identity and tastes (such as home bias, for example), and differences in the depth and the tradability of the market. This effect is therefore related not necessarily to the company's basic nature as an exporter or importer, but to the microstructure of the markets in which the dual-listed stock is traded.

Since the cumulative effect of the exchange rate on the rate of return of a dual-listed stock (economic risk) is economic in nature it should be estimated excluding deviations from the LOOP. Economic risk is caused by the company’s sensitivity to the exchange rate, and therefore affects stock prices and the return on investment in both stock markets in which the dual-listed stock is traded. The risk derives from the company’s basic characteristics, as an exporter exposed to appreciation or an importer exposed to depreciation. Economic risk should thereby affect stock prices in both stock markets in the same direction and at the same intensity, and its effect should also be apparent with a lag. This is in view of the rapidity of the flow of information and the time which it takes the market to assess whether the exchange rate is depreciating or appreciating. The study proposes two alternative ways of calculating the cumulative effect of the shekel/dollar exchange rate on the dual-listed stock's rate of return (economic risk exclusive of the arbitrage effect). The two alternatives were examined in Israel for the simultaneous monthly rates of return of 14 dual-listed stocks during the period 1/2004–12/2010. The findings show that the stocks of natural importers were negatively and robustly affected by a cumulative depreciation, while the effect on exporter's stocks was not uniform. These findings were obtained under both alternatives, and likely derive from the fact that exporters differ from each other in such characteristics as target market, production location, economic industry and competitiveness in it, and even the base currency. This was while the import companies in the sample were relatively homogeneous in their business activity. Finally, economic risk usually had a negligible effect on the rate of return of the stocks in the peer group, which contained companies that are traded in Tel Aviv alone and do not have any substantial import-export activity.

Appendix A: Explanations and examples of arbitrage effects (assuming LOOP holds)

The prices of commodities, such as oil, are usually denominated in dollars since they are products of a global nature. A change in the shekel/dollar exchange rate (assuming all other things being equal) will only change the shekel price of oil, for example, but not its dollar price because Israel is a relatively minor oil consumer. We will now turn to an Israeli patent product which has no competitors worldwide (monopoly) and is exported. This product will be only slightly affected by exchange-rate adjustments since a change in the shekel/dollar exchange rate will be rolled over entirely to the dollar price. Empirical studies that examine the effect of the exchange rate on the pricing of goods in the export and import markets refer to the term Pricing to Market (PTM). If PTM holds completely, any change in the shekel/dollar exchange rate is rolled over by the Israeli (American) exporter to the dollar (shekel) price. Usually, part of the change is rolled over to the dollar price and part is absorbed by the producer. The level of the PTM is determined according to such factors as the manufacturer's markup, the extent of the competition, demand elasticity and price rigidity in the target market (see Knetter 1992; Yang 1998). If the effect of the change in the exchange rate on the price of an export good is taken and divided between the dollar price of the product in the US and its price in Israel (we will denote the divisor between the two markets by $\lambda\ \{1 \geq \lambda \geq 0\}$), it is found to change by stock, time and stock market. In the numerical example below, we will assume that there is no arbitrage opportunity (prem = 0), the price of the stock at time t in Tel Aviv was NIS 40, its price on the NASDAQ amounted to $10, and the shekel/dollar exchange rate was NIS 4 to the dollar. The only economic event between time 0 and 1 was a 5 percent depreciation in the shekel/dollar exchange rate to NIS 4.2 to the dollar. In addition, it is of no significance whether the investor is local or foreign (except for the change in the exchange rate—see Footnote 4). By the numerical example, the depreciation is calculated according to the divisor, λ, for three different values.

	Shekel/dollar exchange rate	λ=0		λ=1		λ=0.7	
		Nasdaq (USD)	Tel Aviv (NIS)	Nasdaq (USD)	Tel Aviv (NIS)	Nasdaq (USD)	Tel Aviv (NIS)
Price: t = 0	4	10	40	10	40	10	40
Price: t = 1	4.2	10	42	9.5	40	38.65	40.60
Rate of change	5%	0%	5%	-5%	0%	-3.5%	1.5%

Note that in the three cases, the arbitrage constraint $\Delta S^{LM} - \Delta S^{US} = \Delta X$ is retained, but the effect of the arbitrage on the rate of return is dependent on the divisor, λ. If λ=0, the entire devaluation is rolled-over to the price in Tel Aviv, and there is no exchange-rate exposure on the investment on the NASDAQ because the dollar price remains fixed. This case is similar to complete PTM on the part of an American manufacturer. However, if λ=1, the entire depreciation is rolled-over to the price on the NASDAQ. In other words, the investment in Tel Aviv is not exposed to the exchange rate (the shekel price remains fixed). In the third case, λ=0.7, the exchange-rate adjustment is distributed as follows: 0.3*5=1.5% is added to the stock rate of return in Tel Aviv and 0.7*5=3.5% is subtracted from the rate of return on the NASDAQ.

Appendix B: Identification ability of the structural equations system—(8a) and (8b)

In order to determine the extent of the identification ability of Equations (8a) and (8b), that is, whether there is under-identification, exact identification or over-identification, we will solve the equations for the two endogenous variables R^{LM} and R^{US} by positioning them in the opposite equations. We initially substitute R^{US} from Equation (8b) in Equation (8a):

(B1)

$$R_t^{US} = \theta_0 + \theta_1 R_{mt}^{US} + \theta_2 L_t^{LM} + \theta_3 L_t^{US} - \theta_4 \sum_{k=0}^{K} \Delta X_{t-k}$$

$$- \theta_5 [m_0 + m_1 R_{mt}^{LM} - m_2 R_{mt}^{US} - m_3 L_t^{LM} - m_4 L_t^{US} + m_5 \sum_{k=0}^{K} \Delta X_{t-k}]$$

$$R_t^{US} = n_0 + n_1 R_{mt}^{LM} + n_2 R_{mt}^{US} + n_3 L_t^{LM} + n_4 L_t^{US} + n_5 \sum_{k=0}^{K} \Delta X_{t-k} + \varepsilon_{2t}$$

Where,

$$m_0 = \frac{\delta_0 - \delta_5\theta_0}{1-\delta_5\theta_5}; m_1 = \frac{\delta_1}{1-\delta_5\theta_5}; m_2 = \frac{\delta_5\theta_1}{1-\delta_5\theta_5}; m_3 = \frac{\delta_2 + \delta_5\theta_2}{1-\delta_5\theta_5}; m_4 = \frac{\delta_3 + \delta_5\theta_3}{1-\delta_5\theta_5}; m_5 = \frac{\delta_4 + \delta_5\theta_4}{1-\delta_5\theta_5}$$

Now substitute R^{LM} from Equation (B1) in Equation (8b):

(B2)

$$R_t^{US} = \theta_0 + \theta_1 R_{mt}^{US} + \theta_2 L_t^{LM} + \theta_3 L_t^{US} - \theta_4 \sum_{k=0}^{K} \Delta X_{t-k}$$

$$- \theta_5 [m_0 + m_1 R_{mt}^{LM} - m_2 R_{mt}^{US} - m_3 L_t^{LM} - m_4 L_t^{US} + m_5 \sum_{k=0}^{K} \Delta X_{t-k}]$$

$$R_t^{US} = n_0 + n_1 R_{mt}^{LM} + n_2 R_{mt}^{US} + n_3 L_t^{LM} + n_4 L_t^{US} + n_5 \sum_{k=0}^{K} \Delta X_{t-k} + \varepsilon_{2t}$$

Where,

$$n_0 = \theta_0 - \theta_5 m_0;\ n_1 = -\theta_5 m_1;\ n_2 = \theta_1 - \theta_5 m_2;\ n_3 = \theta_2 - \theta_5 m_3;\ n_4 = \theta_3 - \theta_5 m_4;\ n_5 = -\theta_4 - \theta_5 m_5$$

From these equalities, it is possible to extract the parameters of the structural equation (8b) exactly. This means that from the run in the limited form of (B1) and (B2), in which the estimates m_i and n_i are obtained {i = 0…5}, it is possible to extract the parameters of the structural equation (θ_i) one-to-one:

$$\theta_5 = -\frac{n_1}{m_1};\ \theta_0 = n_0 + \frac{n_1}{m_1} m_0;\ \theta_1 = n_2 + \frac{n_1}{m_1} m_2;\ \theta_2 = n_3 + \frac{n_1}{m_1} m_3;\ \theta_3 = n_4 + \frac{n_1}{m_1} m_4;\ \theta_4 = n_5 - \frac{n_1}{m_1} m_5$$

Similarly, it is possible to extract the parameters of the structural equation (8b) one-to-one and obtain the parameters δ_i. Now substitute R^{LM} from Equation (8a) in Equation (8b):

(B3)

$$R_t^{US} = \theta_0 + \theta_1 R_{mt}^{US} + \theta_2 L_t^{LM} + \theta_3 L_t^{US} - \theta_4 \sum_{k=1}^{K} \Delta X_{t-k} + \theta_t$$

$$- \theta_5 [\delta_0 + \delta_1 R_{mt}^{US} - \delta_2 L_t^{LM} - \delta_3 L_t^{US} + \delta_4 \sum_{k=1}^{K} \Delta X_{t-k} - \delta_5 R_t^{US} + \delta_t]$$

$$R_t^{US} = l_0 - l_1 R_{mt}^{LM} + l_2 R_{mt}^{US} + l_3 L_t^{LM} + l_4 L_t^{US} - l_5 \sum_{k=1}^{K} \Delta X_{t-k} + \varepsilon_{3t}$$

We will now substitute R^{US} from Equation (B3) in Equation (8a):

(B4)

$$R_t^{LM} = \delta_0 + \delta_1 R_{mt}^{LM} - \delta_2 L_t^{LM} - \delta_3 L_t^{US} + \delta_4 \sum_{k=1}^{K} \Delta X_{t-k}$$

$$- \delta_5 [l_0 - l_1 R_{mt}^{LM} + l_2 R_{mt}^{US} + l_3 L_t^{LM} + l_4 L_t^{US} - l_5 \sum_{k=1}^{K} \Delta X_{t-k}]$$

$$R_t^{LM} = k_0 + k_1 R_{mt}^{LM} + k_2 R_{mt}^{US} + k_3 L_t^{LM} + k_4 L_t^{US} + k_5 \sum_{k=1}^{K} \Delta X_{t-k} + \varepsilon_{4t}$$

Where,

$$k_0 = \delta_0 - \delta_5 l_0;\ k_1 = \delta_1 + \delta_5 l_1; k_2 = -\delta_5 l_2;\ k_3 = -\delta_2 - \delta_5 l_3;\ k_4 = -\delta_3 - \delta_5 l_4;\ k_5 = \delta_4 + \delta_5 l_5$$

From these equalities, we will extract the parameters of the structural equation (8a) one-to-one:

$$\delta_5 = -\frac{k_2}{l_2};\ \delta_0 = k_0 + \frac{k_2}{l_2} l_0;\ \delta_1 = k_1 - \frac{k_2}{l_2} l_1;\ \delta_2 = k_3 - \frac{k_2}{l_2} l_3;\ \delta_3 = k_4 - \frac{k_2}{l_2} l_4;\ \delta_4 = k_5 - \frac{k_2}{l_2} l_5$$

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