בנק ישראל מחלקת המחקר

The Trade–Growth Relationship in Israel Revisited: Evidence from Annual Data, 1960-2004

by

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Abstract

The topic of trade effects on economic growth has been usually controversial. Former empirical evidence linking trade to growth in Israel has been mixed and inconclusive either. This study reexamines the role of trade in Israel by testing for cointegration and causality from both exports and imports to output and total factor productivity over 1960-2004. The results suggest that both output and TFP are positively long-run correlated with exports and imports. The Granger causality tests indicate positive effects of exports on both output and TFP, where imports influence output only. In addition, physical capital has also been found to be Granger-caused by imports. However, it is uncertain whether this finding reflects a true economic causality.

הקשר בין סחר עולמי וצמיחה בישראל

סאלם אבוזאיד

תמצית

נושא ההשפעות של התפתחות הסחר על הצמיחה שנוי במחלוקת. גם הממצאים האמפיריים על הקשר בין הסחר והצמיחה בישראל היו מעורבים, והמסקנות לא היו חד-משמעיות. מחקר זה בודק את תפקיד הסחר בישראל באמצעות מבחני קואינטגרציה ומבחני סיבתיות בין היצוא והיבוא לבין התוצר והפיריון הכולל בתקופה 1960-2004. התוצאות מראות שהן התוצר והן הפריון הכולל מתואמות חיובית בטווח הארוך עם היצוא והיבוא. מבחני סיבתיות גרנג׳ר מראים השפעות חיוביות של היצוא על התוצר והפריון, בעוד שהיבוא משפיע רק על התוצר. בנוסף, נמצא כי הון פיזי נגרם (על פי מבחני גרנג׳ר) על ידי היבוא. יחד עם זאת, לא ברור אם קשר זה משקף קשר כלכלי אמיתי.

1. Introduction

The role of trade in economic growth has been frequently discussed in both theoretical and empirical literature. Although the direction and magnitude of trade effects on output growth are still controversial, literature usually predicts that trade-open economies benefit from integration with their trade partners (Grossman and Helpman, 1991; Wacziarg and Welch, 2003; Kose, Prasad, Rogoff and Wei, 2004).

Traditional trade theories focus mainly on the comparative advantages of international trade, claiming that output levels will be higher when each nation specializes in the production of the commodity of its own comparative advantage (Wacziarg, 1998). A wider acceptance of trade-accelerated growth is credited to the emergence of the endogenous growth theory, pioneered by Romer (1986) and Lucas (1988). This literature provides a more convincing theoretical basis for the positive trade-growth association, mainly through the absorption of new technologies, research and development spillovers, and the enhancement of both specialization and efficiency in production.

Despite this strong theoretical basis, there is still some disagreement in empirical studies regarding the validity of the positive trade-growth relationship.[1] Rodrik (1993) and Krugman (1994) are among the first studies to cast doubts on the cross-nation findings of the early 1990s. Rodriguez and Rodrik (1999), in a very comprehensive study, provide the most critical paper of recent years. They argue for econometric problems and poor measuring of trade-openness that make the results of several previous studies biased in favor of indicating positive trade-growth ties. However, recent papers (e.g., Lee, Ricci and Rigobon, 2004) show that growth is indeed promoted by trade.

The rapid increase in the trade-openness of the Israeli economy makes it a good case study for the issue under discussion. Since 1960, the trade volume as a share of GDP has been rapidly increasing resulting in a ratio of about 70 percent. This increase is mainly due to a large increase in exports, combined by a moderate increase in

[1] See Baldwin (2003) for a discussion on some reasons for this debate.

imports. The fast surge in exports raises the share of Israeli exports of world imports, leading to a rise in Israeli trade volume as a share of overall world trade.

However, despite the increasing reliance of the Israeli economy on its exports sector[2], the lack of any conclusive empirical evidence makes its role uncertain. Hercowitz, Lavi and Melnick (1999) find no effect of trade on Total Factor Productivity (TFP); Lavi and Strawczynski (2001) conclude for "less clear" effects of trade on both output and TFP, whereas the recent study of Bregman and Marom (2005) does report such positive effects. Trade-growth relationship, however, has been the main issue of none of these studies.[3] Therefore, a study that focuses on this nexus is called for. This paper copes with this topic by testing for both long-run relationships and causal links between trade and growth. In particular, direct trade effects on output are examined, combined by testing for indirect association through TFP as suggested in the 'new' growth theory. In addition, because of the debate outlined above, the study presents some sensitivity analysis to ensure the robustness of the obtained results. The findings here are, in general, supportive of the positive gains from trade. Exports, by promoting total factor productivity, seem as an engine for output growth. These conclusions resemble the ones of Bregman and Marom (2005).

The remainder of this paper proceeds as follows. Section 2 presents some theoretical background for trade and growth both in the neoclassical and the endogenous growth theories. Empirical literature dealing with this issue is reviewed in section 3. Section 4 briefly describes the endogenous-theory-based empirical model. Section 5 outlines the empirical methodology utilized here. A description of the major variables in the study is presented in section 6, while section 7 presents the empirical results. Section 8 concludes.

[2] Exports are considered a major engine for the Israeli economic growth (see, for instance, Bank of Israel, Annual Report, 2005, p. 281)

[3] Hercowitz, Lavi and Melnick (1999) examine the impact of macroeconomic variables on TFP; Lavi and Strawczynski (2001) cope with the influence of policy variables on TFP, GDP and production inputs, while Bregman and Marom (2005) discuss the contribution of human capital to productivity and output growth.

2. Theoretical Background

2.1 Growth and Trade in the Neo-Classical Growth Theory

In his very influential closed-economy paper, Solow (1956) defines a production function where output is a function of physical capital stock, labor force and an index of total factor productivity (TFP). He assumes a diminishing return to capital and a constant return to scale function. By these assumptions, output growth is derived either from augmentation of productive inputs (i.e., increase in capital or labor) or from improvements in the efficiency of these inputs (i.e., increase in TFP).[4] A sustainable positive growth rate realizes if the decrease in the capital returns is offset by increase in labor (due to population growth) or if the marginal productivity of capital is increased by technological progress.

This theory has two central assumptions regarding this technical progress. *First*, it believes that technological change is the main source of growth, claiming that output long-run growth rate equals the growth rate of the technological change. *Second*, it considers technical progress as driven by *exogenous* factors.[5] Therefore, in this setting, government policy and public behavior may affect the *level* of output, but not its long-run growth *rate*.[6] Stemming from the above assumptions, trade policy has a long-run positive effect only on the level of output rather than its long-run growth rate. Moreover, since TFP is exogenously determined, trade is not considered as having any effect on improving efficiency or specialization.

[4] Since the TFP shows the growth in output not attributed to augmentation of inputs, it is usually referred to as 'the Solow's residual'.
[5] *i.e.,* the evolution of TFP is determined by non home-country factors.
[6] An influence on the growth rate, however, is possible in the transition stage to the new equilibrium.

2.2 Growth and Trade in the Endogenous Growth Theory

The fall of the Neo-Classical theory in explaining different growth experiences across countries has been a major reason for the emergence of the endogenous growth theory. The beginning of this theory is attributed to Romer (1986), followed by Lucas (1988), Romer (1990) and others.

This theory drops two central assumptions of the neo-classical model. *First*, non-diminishing return to capital; *second*, technological change is endogenous, in the sense that it is provided by forward-looking, profit-maximizing private agents. *Third*, technological opportunities are not the same across nations, thus challenging the convergence assumption suggested by Neoclassicals.

A very significant part of this theory focuses on trade-growth relationships, with Grossman and Helpman (1991, 1991a) among the first theorists to deal with this nexus. In this theory, trade does affect the long-run output growth rate, and not only its level. Specifically, this theory suggests some channels for more trade or more trade-orientation (for instance by lowering trade barriers) to speed up long-run economic growth.[7] The main channels considered are (1) encouraging greater specialization and stimulating efficiency of domestic producers to compete in international markets; (2) allowing for or easing the absorption of new foreign technologies; (3) leading to more rapid introduction of new products and services; (4) reducing price distortions in favor of price equalization; and (5) leading to larger economies of scale in production.

As a part of endogenizing technological change, trade gains high attention in this process. Grossman and Helpman (1991), Coe, Helpman and Hoffmaister (1997), Barro and Sala-i-Martin (1997), Wacziarg (1998), Miller and Upadhyay (2000) among others, claim positive trade-TFP association. These studies consider trade as a main channel for the spread of new ideas, knowledge and technologies between nations. Trade facilitates an economy's access to new foreign innovations, thus allowing for easier and more efficient adoption of new production techniques (Edwards, 1992). This stems either from direct imports of high technology goods or

[7] See Salvatore (1998) for a detailed discussion.

from more interaction with the sources of these innovations. Coe and Helpman (1995) highlight the international R&D spillovers, arguing that foreign R&D encourages domestic TFP, where imports play a central role in this process. Specifically, the higher the share of imports from a specific trade partner in overall imports, the larger is the effect of that partner's R&D on the domestic TFP. Another argument linking trade to TFP, formulated by Holmes and Schmitz (2001), is that greater openness leads to a redistribution of resources from non-productive to productive activities, thus boosting TFP.

In this theory, human capital is considered another basic ingredient in the formulation of TFP since, for given stocks of labor and physical capital, higher human capital is most likely to be associated with higher productivity.[8] Romer (1990a) claims that human capital affects TFP by determining the capability of economies to innovate new technologies suited for production.

3. Empirical Literature Review

Over the last two decades the role of trade in stimulating economic growth has been the topic of several empirical studies. Due to diverse trade measures and the different issues examined, literature is still debated whether more trade (or more trade orientation) is an ingredient of enhanced economic development.

Although theoretical literature usually focuses on the effects of trade *policy* on economic growth, most empirical studies examine the effects of *actual* trade (or trade volume) rather than trade policy (Harrison, 1996).[9] Using such measures, Quah and Rauch (1990), Helliwell and Chung (1992), Frankel and Romer (1999) among others, support the positive effect of trade in economic growth.

The major class of trade-growth studies has been focusing in the popular Export-Led Growth (ELG) hypothesis, believing that only exports are significant for sustainable economic expansion. Numerous studies examine its validity for various types of

[8] For instance, as the work force becomes more educated, the labor productivity is supposed to increase.
[9] Among the studies that examine the impact of trade policy are Edwards (1998) and Yanikkaya (2003).

countries.[10] Employing time-series techniques, Thornton (1996), Ghatak *et al* (1997) and Awokuse (2005) among others, show that output has been driven by exports in Mexico, Malaysia and Japan, respectively. Dar and Amirkhalkhali (2003) support this hypothesis for a group of 19 OECD countries, where the magnitude of exports impact on growth increases with the degree of openness.

However, despite its popularity, both cross-section and times-series readings cast doubts on the ELG validity.[11] Some studies show that exports are insignificant for economic growth (e.g., Jung and Marshall, 1985; Kugler, 1991; Sharma and Panagiotidis, 2005). Others, as Oxley (1993) and Henriques and Sadorsky (1996), argue for only a reverse causation running from output to exports (named Growth-Driven Exports). Some other scholars, as Dodaro (1993) and Doyle (2001), establish bidirectional causality from exports to output and vice versa.

Another group of studies, occasionally referred to as Import-Led Growth (ILG), highlights the contribution of imports to economic activity,[12] usually through its impact on total factor productivity. Lawrence and Weinstein (1999) show that imports have been supportive of total factor productivity in Japan, Korea and the United States. Coe and Helpman (1995) show that imports spur productivity by enhancing R&D spillovers among nations. Serletis (1992), contrarily, fails to indicate a causal relationship from imports to output growth.

In Israel, some of the empirical papers of the last decade deal with the role of trade in economic growth. Hercowitz, Lavi and Melnick (1999) employ a cointegration and causality approach to test for the impact of macroeconomic factors on TFP over 1960-1996. Trade openness (measured as the exports-GDP ratio) has been found to be neither cointegrated with TFP nor causing it. In their times-series study on the influence of policy variables on output, TFP and production factors during the period 1960-1995, Lavi and Strawczynski (2001) have not been conclusive about the role of

[10] See Gils and Williams (2000) for the most comprehensive review of this literature.
[11] Refer to Ghatak *et al* (1997) who review different outcomes of several studies between the mid 1980s and mid 1990s.
[12] In their seminal study, Riezman, Summers and Whiteman (1995) argue that omitting imports may make the ELG causality tests misleading. Specifically, excluding imports may either mask a true significant exports-to-output causality, or cause a spurious one. In addition, they show that a two-stage causal chain, running form exports to imports to growth, exists.

trade openness (measured as in the previous study) in the evolution of these variables. This result reflects positive long-run coefficients of trade openness in some specifications from one side, and no improvement in the overall cointegration relationship (measured by the magnitude and significance of the ADF statistic), from the other. Using quarterly data for the period 1990-2000, the Granger causality test in Flug and Strawczynski (2002) indicates a positive impact of high-tech exports on output over 1997-2000, where such relationship has not been observed for the whole examined sample. Finally, referring to the trade volume-GDP ratio as the index of trade, Bregman and Marom (2005) have recently been supportive of the positive influence of trade on output and TFP growth over 1970-1999.

4. Short Empirical Model: Trade, Total Factor Productivity and Output

My empirical model starts from the following simple neoclassical production function form:

(1) $Y_t = A_t K_t^{\alpha} L_t^{\beta} e^{\varepsilon_t}$,

where: Y_t denotes the aggregate output, A_t -the level of Total Factor Productivity, K_t -the physical capital stock, L_t -the stock of labor and ε_t is an error.

Aligned with the endogenous growth theory, the TFP is expressed as a function of trade measure (exports, imports, trade volume or any other measures), a human capital index and other factors which may influence TFP (denoted by T, H and C in (2), respectively). For simplicity, the function of TFP is assumed to be of Cobb-Douglas type[13].

(2) $A_t = T_t^{\gamma} H_t^{\delta} C_t$.

Substituting eq.(2) into eq.(1) yields:

(3) $Y_t = C_t K_t^{\alpha} L_t^{\beta} H_t^{\gamma} T_t^{\delta} e^{\varepsilon_t}$.

Taking natural logarithms (ln) gives the following linear function:

(4) $\ln Y_t = \ln C_t + \alpha \ln K_t + \beta \ln L_t + \gamma \ln H_t + \delta \ln T_t + \varepsilon_t$.

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[13] In this formulation, I follow Herzer, Nowak-Lehmann and Siliverstovs (2004).

Each coefficient in (4) represents the output elasticity in respect to the particular variable. Moreover, unlike Neoclassicals (e.g., Mankiw, Romer and Weil, 1992) in the above formulation I do *not* restrict the sum of elasticities to equal 1, thus allowing for non-constant return to scale function.

Equation 4 serves here as the benchmark model to test for trade-GDP relationships. To test for the robustness of the results obtained from this equation, I carry out different robustness checks, by either adding other possible determinates of GDP (e.g., fiscal policy variables) or changing the patterns of my specifications (e.g., normalizing variables by the labor index). A detailed discussion on the possible effects of other variables is presented in subsection 6.2, where the results are described in subsection (7.2.1.1).

Moreover, following the theoretical considerations presented earlier, the study tests for the trade-TFP relationship, with human capital as a major variable in the system. Effects of other variables on TFP are examined as well (see subsections 6.2 and 7.2.2).

5. The Empirical Methodology:

5.1 Unit Root Tests: In order to investigate the stationarity properties of the data, unit root tests are carried out using the Augmented Dickey-Fuller approach developed by Dickey (1976) and Dickey and Fuller (1979). This test is employed by estimating the following regression:

$$\Delta x_t = \alpha_0 + \alpha_1 t + \beta x_{t-1} + \sum_{j=1}^{p} \delta_j \Delta x_{t-j} + \varepsilon_t \,,$$

where α_0 a drift, t is a time trend and p is the selected lag length[14]. The null hypothesis is that the variable x is nonstationary $(H_0 : \beta = 0)$, and it is rejected if the β is negative and significantly different from zero.

Note however, that in case of a structural break, the ADF test tends to indicate unit root even if the series is indeed stationary. Therefore, in a case of nonstationary first differences, the Perron (1989) test is employed since it embodies such a break. Carrying out this test could be essential since, as described later, the Israeli macroeconomic series have been experiencing some breaks during the investigated period (e.g., the oil crisis and the mass migration from the former USSR).

5.2 Cointegration: If all variables are of the same degree of integration, a test for cointegration will be processed. Generally, a set of variables is said to be cointegrated if it exhibits a long run-run relationship. This is the case if a linear combination of the nonstationary individual series is stationary $I(0)$ (Engle and Granger, 1987).

To test for cointegration I use the Johansen (1991, 1995) approach, which allows both to test and estimate for multiple cointegration vectors in a single step**.** This method is based on the following unrestricted vector autoregression:

$$\Delta y_t = \Pi y_{t-i} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + B x_t + \varepsilon_t \,.$$

The Johansen method is to estimate the Π matrix from an unrestricted VAR since its rank is the number of cointegrating vectors.

[14] The optimal lag length p is determined using the Schwartz Information Criterion (SIC) proposed by Schwartz (1978).

5.3 Vector Error Correction Models (VECM): If all the variables are $I(1)$ processes, letting $\Delta y_t = y_t - y_{t-1}$, it is possible to formulate a vector error-correction (VEC) equation as follows:

$$\Delta y_t = \mu + \alpha \mathrm{ECT}_{\mathrm{t-1}} + \sum_{k=1}^{p-1} \beta_{yx,k} \Delta x_{t-k} + \sum_{k=1}^{p-1} \beta_{yy,k} \Delta y_{t-k} + \ldots + \varepsilon_t ,$$

where, μ is a constant, $\mathrm{ECT}_{\mathrm{t-1}}$ is the error correction term lagged one period, and $\beta_{ij,k}$ represents the effect of the kth lagged value of variable j on the current value of variable i. Specifically, if a lagged value of some variable is significant, then causality runs from that variable to the dependent variable. Therefore, in the causality subsection we will report the significance tests results for the trade variables. In addition, the study will report the results for the coefficient α, which represents the speed of adjustment to equilibrium. Significant α means that any deviation from the long-term relationship is corrected in subsequent periods, thus making the system turn back to equilibrium.

5.4 Standard Granger Causality Tests: The last step of the empirical work is testing for causality ordering between my variables. According to Granger (1969), *y* is said to be caused by *x*, if the forecast for *y* is improved (has a smaller mean square error) by using both the historical values of *x* and *y* rather than by using its own past values only. The hypothesis that *y* is caused by *x* can be examined by estimating the following equation:

$$y_t = \mu + \sum_{i=1}^{p} \beta_{11i} y_{t-i} + \sum_{i=1}^{p} \beta_{12i} x_{t-i} + \varepsilon_t ,$$

in which, μ is a constant and ε_t represents a white noise process.

Variable *y* is said to be Granger-caused by *x* if at lease one β_{12i} is significantly different form zero.

This type of causality tests is to be employed in the case of no cointegration.

6. Data

The empirical analysis is based on annual data covering the period 1960-2004. For complete and detailed definitions of the variables, see Appendix 1.

6.1. Main Data Description

In this subsection, I present brief descriptions of my main variables (GDP, Trade, and TFP), and discuss the measuring of trade-openness and human capital.

6.1.1 Trade and Growth in Israel

Figures 1 and 2 show the evolutions in the Israeli GDP, the trade volume in goods and its components (exports and imports) respectively. All the variables grew at relatively fast rates until the oil crisis of 1973, but experienced a crash in growth rates in the last three decades. Despite some increase in growth rates since the beginning of the 1990s, largely due to the immigration from the former Soviet Union, they still very low compared to the pre-crisis period.

Figure 1: The natural logarithm of GDP in Israel: 1960-2004

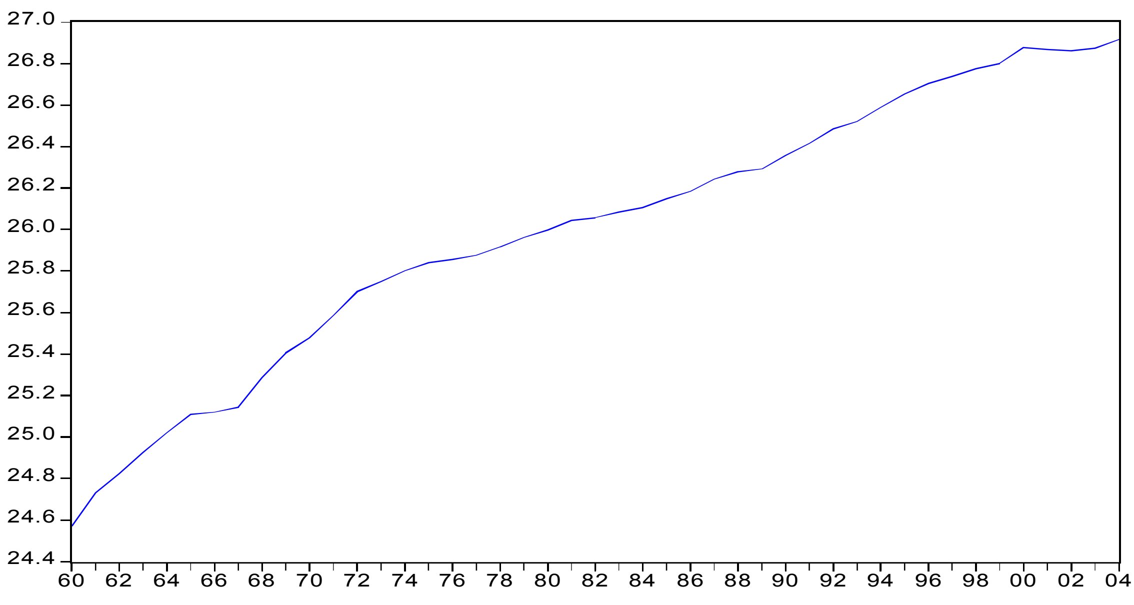
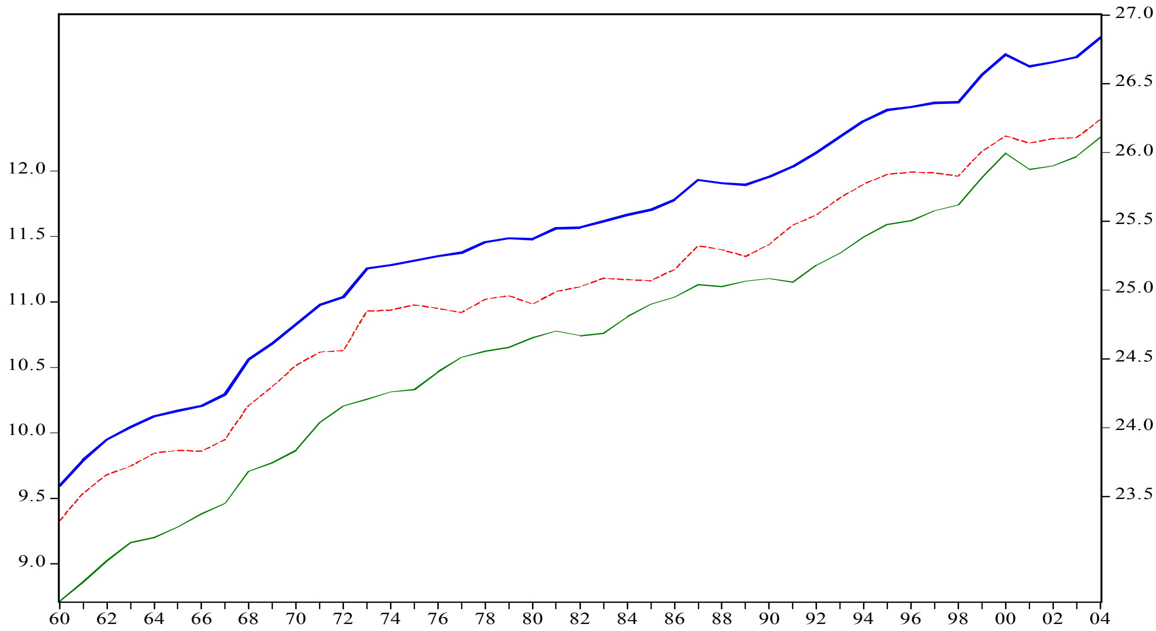


Figure 2: The natural logarithms of Exports, Imports and Trade Volume in Israel: 1960-2004



Thick line-Trade Volume (right-hand axis); Thin line-Exports; Dashed line-Imports (left-hand axis).

6.1.2 Measuring the Degree of Trade Openness: One serious difficulty researchers usually face is measuring the trade openness degree. Therefore, the empirical literature on trade and growth suggest various indicators to measure it[15]. For time-series studies, *the ratio of trade volume (exports plus imports) to GDP* is the simplest one (Harrison, 1996). The two main reasons for its attractiveness are (i) its availability compared to other indices (Belke and Wang, 2005), and (ii) the fact that it reflects the effective degree of integration (Wacziarg, 2000). This measure has been used in several studies (e.g., Ghatak, Milner and Utkulu, 1995; Harrison, 1996; Weinhold and Rauch, 1997; Frankel and Romer, 1999).

The increase in the trade openness of the Israeli economy is well illustrated in figure 3. A deep inspection of this ratio shows that the increase of the trade-GDP ratio was mainly due to higher exports growth than imports growth. Precisely, since 1960, exports more than tripled while imports only doubled.

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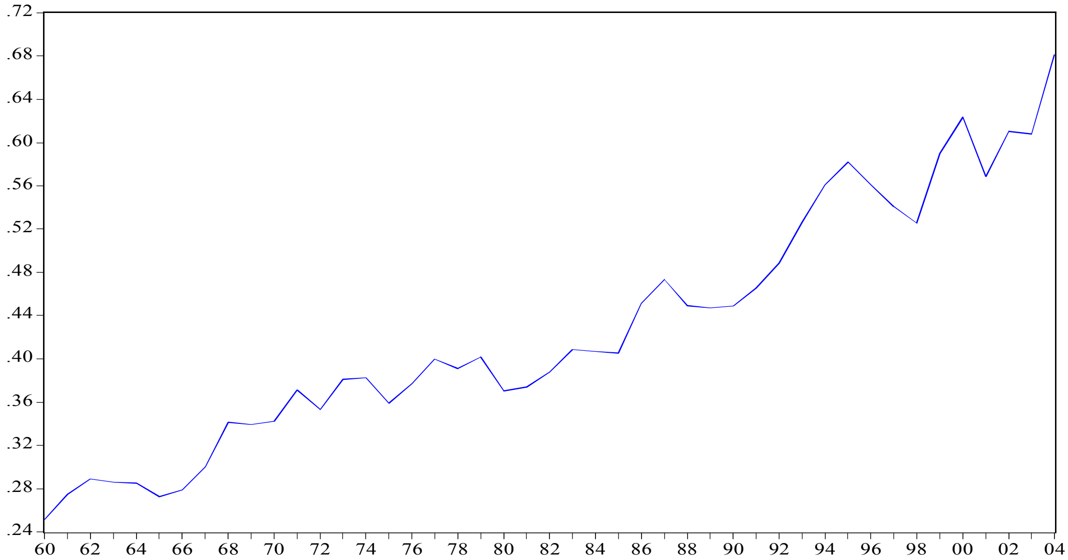
[15] See Harrison (1996), Edwards (1998) and Rodriguez and Rodrik (2000) for comprehensive reviews of these measures.

Figure 3: the evolution of the Israeli Trade Openness, 1960-2004



6.1.3 Trade-Growth Relationships: The Issue of Measures

Former studies dealing with the role of trade in the Israeli economic growth usually refer to trade-GDP ratios as indices of trade. Although this measure is considered as the most preferable measure for the *actual trade-openness degree*, it is less favorable in testing for trade effects on GDP or TFP. *First*, this variable is itself a function of output: for a given trade volume, this measure is lower the higher the output is. Therefore, the final conclusion of regressing output on this measure is possibly biased by this endogeneity. For instance, if this measure does not increase (e.g., due to slower trade growth compared to GDP growth), then even a negative relationship may be obtained. *Second*, regressing GDP or TFP on this index shows whether higher *trade-openness degree* is associated with faster growth (or higher output levels). However, this is not necessarily the accurate question, since trade may be growth-promoting even if the *degree of openness* stays unchanged. In this sense, even in these years where the Israeli trade-openness degree decreases, the economy still benefits from international trade. *Finally*, this measure is very volatile from one period to another (figure 3), whereas output evolution is usually more solid. Therefore, in specific years it may "miss" the right (positive) trade-GDP connection.

Stemming from these considerations, *besides the trade-GDP ratio (TVY)*, this study refers to several trade measures to test for role of trade.[16] *The trade volume in absolute values (TV)* shown above serves as the main one here. The use of trade volume has several advantages. *First*, it shows the actual quantitative gain form a given increase in trade volume (or any of its components). *Second*, a regression of this measure with growth better shows whether an increase in trade is supportive of growth. Therefore, it enables to identify true trade effects even in times of fall in the openness degree. *Third*, compared to the trade-GDP ratio, this variable is *less* affected by endogenieties. *Finally*, its relatively solid evolution helps to establish a more stable relationship. Using this class of trade measures is very common in times-series studies (see, for example, Kugler, 1991; Marin, 1992; Henriques and Sadorsky, 1996; Thornton, 1996 and others[17]).

The *share of the Israeli trade volume in world trade (TVWT)* is another measure to test for this nexus. Using this variable shows the trade effects when the absolute values of trade are normalized to some exogenous measure. The shares of Israeli exports in world imports and Israeli imports in overall world exports are also considered. In addition, for a similar consideration, the *per capita trade volume (TVPC)* is used here[18].

Finally, since this study tests whether *actual* trade has been growth-promoting along the examined period, only *ex-post* trade measures are utilized. Having the inconclusive findings of previous studies, a focus on this question solely is required. Other issues, as the appropriate growth-promoting trade *policy*, are not discussed here although they are of high significance. Moreover, trade policy measures do not always go in line with the actual trade volume (Edwards, 1998), thus possibly suggesting considerably different relationships with growth (Yannikaya, 2003). An examination of the desired trade policy is more applicable if based on some historical empirical investigation that either supports the positive role of trade or refutes it.

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[16] Corresponding measures for exports and imports are also used: exports and imports in absolute values (EX, IM), exports and imports per capita (EXPC, IMPC), exports as share of world imports (EXWM) and imports as share of world exports (IMWX).

[17] Among other studies that use this variable are Ukpolo, 1994; Dar and Amirkhalkhali, 2003; Sharma and Panagiotidis, 2005; Shan and Tian, 2000; Awokuse, 2003,2005.

[18] I am grateful to Ya'acov Lavi for his suggestion to include this variable.

6.1.4 Total Factor Productivity in Israel

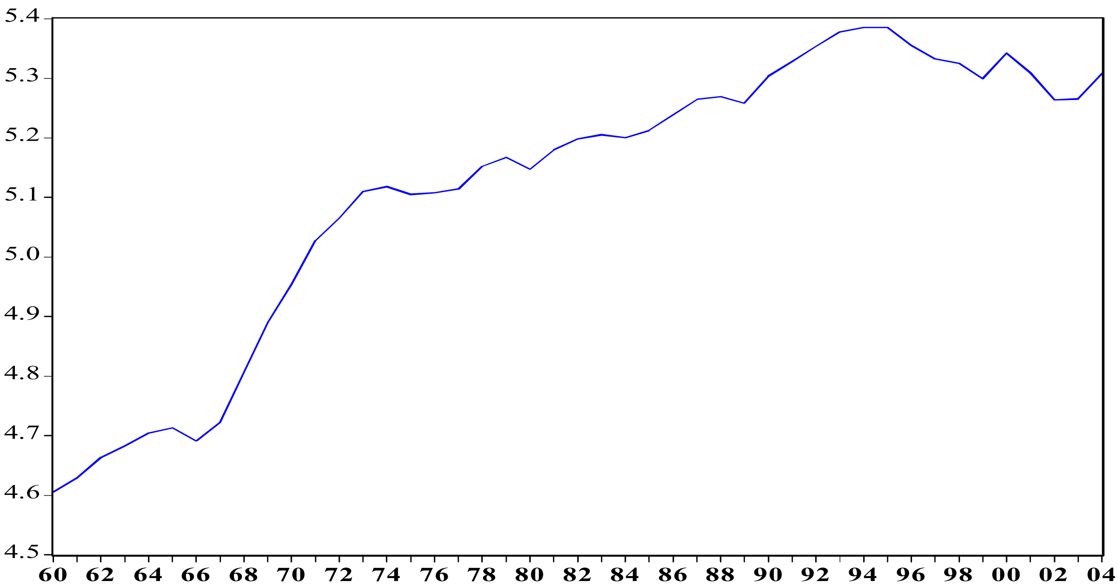
As previously noted, Total Factor Productivity (TFP) measures the output growth not credited to the augmentation of production factors. It is calculated as a residual from a constant return to scale production function with labor and physical capital as the only inputs.

$$A_t = \frac{Y_t}{K_t^{\alpha} L_t^{1-\alpha}}.$$

Differentiating by time gives the so-called Solow's residual equation:

$g_A = g_Y - \alpha g_K - (1-\alpha) g_L$, with g as the growth rate of a particular variable.

Figure 4: The natural logarithm of Total Factor Productivity in Israel, 1960-2004.



The Israeli TFP is shown in figure 4.[19] Until 1972, it experienced high growth due to high output growth and moderate labor growth. After the oil crisis and the Yom-Kippur War it continues to grow, but with very modest rates. The sharp increase in the labor force resulting from the mass migration from the former USSR in early 1990s combined by high investments led to the decline in TFP since 1993. This decline reflects low output growth rates compared to inputs growth rates (i.e., the extremely high growth in capital and labor was not accompanied by a corresponding

[19] In line with previous studies and the Bank of Israel assumption, the TFP is calculated using $\alpha = 0.32$.

output growth).[20] Consequently, the contribution of TFP to the overall output growth in the last 11 years is only a half of its contribution prior to the mass migration (table 1). In general, 30 percent of the GDP growth in the last 45 years is credited to TFP growth. This estimate is similar to that of Helpman (2003) who focused on Israeli growth during the period 1971-1990. In comparison, the contribution of TFP averaged 50 percent in OECD countries and 30 percent in Latin American countries (Levine and Easterly, 2002).

The shares of growth contributed by the physical capital (40 percent) and labor (30 percent) are acceptable estimates. As reviewed in Levine and Easterly (2002), the capital share averaged 50 percent in OECD and 40 percent in both Latin American and East-Asian countries. The labor shares in OECD, Latin American and East Asian nations have been around zero[21], 25 percent and 35 percent, respectively. Therefore, the contributions of the various components to the Israeli output growth are closer to these in less developed countries than in developed ones.

Table 1: GDP growth decomposition, by Subperiods, in percents, 1960-2004

Subperiods	Labor	Capital	TFP
1960-1972	-9.8	60.9	49.0
1973-1989	23.9	51.0	25.1
1989-1993	37.1	21.2	41.6
1994-2004	82.5	5.2	12.3
1960-2004	**30.6**	**39.5**	**29.9**

6.1.5 Measuring Human Capital in Israel

The role of human capital in the process of economic growth has been the topic of various studies. Considering human capital allows for worker heterogeneity, thus suspending Solow's assumption of a homogenous labor force. Several proxies have been proposed to measure human capital.[22] *School enrollment ratios* are among the first and most frequently used measures of human capital (e.g., Barro, 1991; Levine and Renelt, 1992; Mankiw *et al.*, 1992 and Akinlo, 2005). This index shows the ratio

[20] For more discussion on the Israeli TFP since 1960, see Hercowitz, Lavi and Melnick (1999).

[21] Although the estimates vary from (-8) to 42 percent, most of the OECD countries reviewed have a share of roughly zero.

[22] See Wößmann (2000) for an excellent review of human capital measures.

between the number of pupils enrolled at some grade level (e.g., secondary school) and the number of habitants in the corresponding age group.[23] Following the above readings, this study refers to the enrollment ratio as the *main* measure of human capital. To ensure the results obtained on one side and to consider an index that better reflects the Israeli human capital in the last few years, on the other, some of my major specifications are rerun using another human capital measure-the share of population with at least 13 schooling years. Using this index is in line with some previous studies in Israel (e.g. Lavi and Strawczynski, 2001; Flug and Strawczynski, 2002).

6.2 Other Variables and Their Expected Effects

The effects of other variables on GDP and TFP growth are presented in this subsection.

Fiscal policy: the existing literature extensively discusses the impact of fiscal policy on growth, suggesting several channels for this impact. Government actions may influence growth both by causing productivity and investments. As for TFP, Government activities play a role in the allocation of resources, thus influencing productivity. The overall influence of governments on TFP is, however, controversial. As pointed by Levine and Renelt (1992), governments may, on one side, provide public goods to promote growth, whereas on the other, they may waste resources in financing *non*-growth-promoting activities. In addition, theories argue that taxes necessary to finance government spending may distort agents' incentives and decisions, thus reducing the efficiency of resources allocation (Levine and Renelt, 1992; Bregman and Marom, 1993; Akinlo, 2005).[24]

The literature is inconclusive also about the direction of fiscal policy affect on physical capital. Theoretical predictions suggest negative effect of government size (as measured by its total expenditures to GDP) on physical capital accumulation, possibly due to more crowding out of investments (Levine and Renelt, 1992). In addition, higher government expenditure is more likely to be associated with higher

[23] As pointed out by different authors, this measure better describes the flow of human capital than its stock. However, all other human capital measures have their own disadvantages and none is a perfect measure of human capital.

[24] Note, however, that the impact on productivity is largely related to its allocation, since disaggregated government spendings may have diverse influences on productivity. Identifying the different effects of disaggregated spendings is not tested here.

budget deficits, which usually adversely affect capital accumulation (Fischer, 1993). The analysis of Levine and Renelt (1992), contrarily, finds no robust negative fiscal policy effect.

In the current study, I add total government expenditures (both absolute value and as share of GDP), total taxes-GDP and deficit-GDP ratios as measures of fiscal policy. The empirical tests here focus mainly on the effects of fiscal actions on TFP.

Standard deviation of inflation: following Fischer (1993), I use this variable as a measure of macroeconomic instability. The variability of inflation provides a signal for an unstable macroeconomic system and possibly less budget control. Therefore, it could be harmful for economic growth either by reducing capital accumulation or total factor productivity.[25] The results of Fischer (1993) show that a higher inflation rate and higher inflation variability reduce capital accumulation, while higher inflation rate has a negative effect on TFP. His finding regarding capital accumulation is consistent with the strong negative effect of inflation on investments shown by De Gregorio (1993).

The U.S. TFP: this variable serves to test for possible exogenous effects on the Israeli TFP. The evolution of the U.S. TFP is used since it represents the leading world technology and therefore it best reflects technology diffusion. This test is in line with Hercowitz, Lavi and Melnick (1999), Lavi and Strawczynski (2001) and Véganzonès and Winograd (1998), who all show that domestic TFP is positively correlated with U.S. TFP.

Roads capital stock: I follow previous studies (e.g., Hercowitz *et al.*, 1999; Flug and Strawczynski, 2002) and incorporate this measure in my TFP estimations, since expenditures on roads infrastructure encourage productivity by promoting the efficiency of production factors.

[25] One channel for Inflation variability to affect TFP is that economic uncertainty, through inducing excess capacity, may reduce factor utilization. For further discussion see Hercowitz *et al* (1999).

7. Empirical Results

7.1 Unit Root Tests

The ADF test results are reported in table 2 both for the levels and the first differences of my main variables. For other variables, refer to Appendix 2.

Table 2: ADF unit roots tests, 1960-2004

	Level			First difference		
	statistic	*Critical (5%)*	*Critical (10%)*	*statistic*	*Critical (5%)*	*Critical (10%)*
GDP	-2.03	-3.51	-3.19	-1.61	-1.95	-1.61
TFP	-0.86	-3.51	-3.19	-4.16	-1.95	-1.61
TFPM	-2.77	-3.54	-3.20	-5.46	-1.95	-1.61
L	-1.66	-3.53	-3.20	-3.01	-1.95	-1.61
K	-2.88	-3.52	-3.19	-1.92	-1.95	-1.61
H	-3.08	-3.51	-3.19	-3.87	-1.95	-1.61
YS13	-2.51	-3.52	-3.19	-7.25	-1.95	-1.61
TV	-2.88	-3.51	-3.19	-2.94	-1.95	-1.61
TVY	-3.17	-3.51	-3.19	-6.23	-1.95	-1.61
TVWT	-2.58	-3.51	-3.19	-7.40	-1.95	-1.61
TVPC	-1.77	-3.51	-3.19	-3.91	-1.95	-1.61
EX	-3.16	-3.51	-3.19	-2.00	-1.95	-1.61
EXY	-2.30	-3.51	-3.19	-5.23	-1.95	-1.61
EXWM	-2.76	-3.51	-3.19	-3.76	-1.95	-1.61
EXPC	-2.99	-3.51	-3.19	-2.62	-1.95	-1.61
IM	-2.64	-3.51	-3.19	-3.76	-1.95	-1.61
IMY	-2.83	-3.51	-3.19	-7.33	-1.95	-1.61
IMWX	-2.56	-3.51	-3.19	-7.79	-1.95	-1.61
IMPC	-2.73	-3.51	-3.19	-3.76	-1.95	-1.61

Note: The critical values are from Mackinnon (1996).

The results show that all the variables are nonstationary in their levels, and that all, except GDP, are stationary in their first differences.[26] I presume that the result of D(GDP) is biased because of the structural break in 1973. By employing the Perron (1989) test, the first difference of this variable has been found to be stationary.[27] I conclude that all my variables are integrated of order one ($I(1)$).

[26] The D(GDP) is nearly stationary in 10 percent (the statistic and critical values are almost equal).
[27] The statistic value is (-1.71). Considering the structural break in 1990 either, the statistic value has been found to be (-1.77).

7.2 Cointegration Tests and Cointegration Vectors

Since all variables are of the same integration order ($I(1)$), cointegration tests between different sets of variables are processed using the Johansen technique. [28]

7.2.1 Trade and Output

In this subsection, I test for the validity of trade-GDP cointegrating relationships both in my multivariate benchmark model and in a bivariate model with trade and GDP as only variables. To check for the robustness results obtained using the trade volume, I retest these models using other trade openness measures. Table 3 summarizes these tests.

Table 3-Johansen cointegration tests results.

Model	**Max-Eigenvalue Test**				**Trace Test**			
	H_0	H_1	***Statistic***	***Critical Value*** $(\alpha = 5\%)$	H_0	H_1	***Statistic***	***Critical Value*** $(\alpha = 5\%)$
1	$r=0$*	$r=1$	46.97	33.88	$r=0$*	$r\leq1$	74.11	69.82
	$r=1$	$r=2$	17.78	27.58	$r\leq1$	$r\leq2$	27.14	47.86
2	$r=0$.	$r=1$	51.43	33.88	$r=0$*	$r\leq1$	80.54	69.82
	$r=1$	$r=2$	20.04	27.58	$r\leq1$	$r\leq2$	29.11	47.86
3	$r=0$*	$r=1$	59.93	33.88	$r=0$*	$r\leq1$	92.31	69.82
	$r=1$	$r=2$	23.70	27.58	$r\leq1$	$r\leq2$	32.38	47.86
4	$r=0$*	$r=1$	52.29	33.88	$r=0$*	$r\leq1$	94.67	69.82
	$r=1$	$r=2$	23.38	27.58	$r\leq1$	$r\leq2$	38.38	47.86
5	$r=0$*	$r=1$	21.39	14.26	$r=0$*	$r\leq1$	24.56	15.50
	$r=1$	$r=2$	3.17	3.84	$r\leq1$	$r\leq2$	3.17	3.84
6	$r=0$*	$r=1$	21.34	14.26	$r=0$*	$r\leq1$	24.75	15.50
	$r=1$	$r=2$	3.41	3.84	$r\leq1$	$r\leq2$	3.41	3.84
7	$r=0$*	$r=1$	16.93	14.26	$r=0$*	$r\leq1$	18.53	15.50
	$r=1$	$r=2$	1.61	3.84	$r\leq1$	$r\leq2$	1.61	3.84
8[29]	$r=0$*	$r=1$	15.11	14.26	$r=0$	$r\leq1$	15.11	15.50
	$r=1$	$r=2$	0.01	3.84	$r\leq1$	$r\leq2$	0.01	3.84

Notes: * denotes rejection of the hypothesis at the 5% level. The critical values are from Haug, Mackinnon and Michelis (1999). The corresponding vectors are presented in table 4.

[28] When testing for cointegration, I do *not* assume that trade and GDP (or TFP later on) should be in equilibrium, but rather due to econometric needs resulting from the nonstationarity of the series.

[29] Both the Trace and Max tests indicate 1 cointegration vector when adding a dummy variable that capture the large increase of population in the beginning of the 1990s.

The results indicate long-run relationships in each case. The Max-Eigenvalue statistic shows that for all cases a unique cointegration vector exists, while the trace statistic indicates a unique vector in 5 out of 6 cases, and none in one case (model 8). I follow the Max-Eigenvalue statistic [30] and report the unique cointegration vector (table 4).

Table 4: Cointegration Vectors of various variables with GDP.

Var.	1	2	3	4	5	6	7	8
K	0.399	0.651	0.720	0.559				
L	0.095	0.102	0.211	0.224				
H	0.227	0.322	0.218	0.278				
TV	0.347				0.756			
TVY		0.506				3.080		
TVWT			0.138				3.782	
TVPC				0.229				1.279
Const.	5.789	8.248	5.675	6.724	6.796	27.625	46.723	12.878

Notes: All variables are in natural logarithms. Dependent Variable: Natural Logarithm of GDP.

As expected, my benchmark model indicates positive long-run relationships between the output and the other variables. The coefficient of the trade volume in model 1 is around 0.35. The use of other trade variables confirms my finding regarding the trade-GDP positive long-run correlation. The coefficient of the trade volume-GDP ratio (TVY) is larger than the trade volumes' one, possibly due to endogenieties. The Israeli trade as a share of world trade (WT) and the trade per capita (TVPC) are also positively related to output, although with moderate coefficients (models 3 and 4, respectively).

Having output positively correlated with trade and other output determinants, I check if these trade-GDP linkages hold when dropping all other variables. This test is essential since the long-run ties found above may result from the linkages of GDP with variables rather than with output. Identifying cointegration in a bivariate system will confirm that a part of the long-run relationship in a multivariate model is due to a true trade-GDP relationship. The results of the Johansen tests in table 2 show that the different trade variables are indeed positively cointegrated with output (models 5 through 8, table 4). To sum up, all the above specifications show that trade and GDP

[30] In a case of contradiction regarding the number of vectors, the number found by Max will be chosen.

exhibit a long-run relationship. Moreover, since the results using TVY, TVPC and TVWT are all consistent with those obtained by using TV, this subsection proceeds with the latter as the only trade variable.

The elasticity of output to physical capital is roughly 0.40, an acceptable estimate for Israel.[31] GDP-labor elasticity is found to be around 0.10 while the human capital coefficient is roughly 0.20.[32] Since the labor coefficient seems lower than expected, it should be noted that a part of its effect on output is embodied in the human capital coefficient. This result is consistent with the growth theory that highlights labor heterogeneity.[33] According to this theory, the production function may include a human capital-augmented labor input rather than labor input alone, or separate labor and human capital inputs. Therefore, summing the two coefficients shows that "real" labor elasticity is around 0.30. This estimate resembles that of Plumper and Graff (2001) who find a sum of 0.37 for a sample of 90 developed and developing countries. The coefficient of the education-augmented labor input is roughly 0.25, very close to the previous estimate (Table 1, Appendix 3). In this setting too, the GDP-trade and GDP-capital elasticities are similar to those reported above.

Some notable result arises from my estimates: the physical-capital-trade relationship.[34] As can be seen in table 5 below and Table 1 of Appendix 3, dropping the trade volume from the benchmark specification yields much higher capital coefficient (roughly 0.75) whereas the sum of human capital and labor elasticities remains unaltered. The 0.75 [35]capital coefficient is approximately the sum of the trade and capital elasticities reported earlier. Consequently, this finding may hint that, for some reason, the coefficient of physical capital in a trade-excluded specification embodies the contribution of trade to growth.

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[31] For instance, Lavi and Strawczynski (2001) report a coefficient of 0.34.

[32] The coefficient of the other human capital measure (the share of population with 13 schooling years or more is similar-between 0.23-0.27). The results are unreported here.

[33] See Wößmann (2000) for a detailed discussion.

[34] The study refers this issue later when discussing the possible role of imports in the process of physical capital accumulation.

[35] Cross-country studies found similar estimates for K: 0.63 in Plumper and Graff (2001), 0.64-0.87 in Benhabib and Spiegel (1994) and 0.67-0.74 in Benhabib and Spiegel (2001).

Finally, long run relationships have been observed also when replacing trade volume by exports and imports (Tables 2 and 3, appendix 3). Precisely, exports measures exhibit long-term ties with trade in all the 8 cases discussed before while imports establish such relationships in 7 of these 8 cases. The only case where cointegration has been rejected is the bivariate model with output and the Israeli imports as share of world exports (IMWX). This result is unsurprising since the latter variable has been very volatile along the investigated period.

Table 5: Cointegration Vectors of various variables with GDP, with trade excluded.

Variable	1	2	3
K	0.786	0.724	0.835
L	0.133	0.306	
H	0.242		0.370
Const.	4.017	3.646	4.252

Notes:All variables are in natural logarithms.
Dependent Variable: Natural Logarithm of GDP.
[+] The unreported formal cointegration tests indicate log-run relationships.
Tests results are available by order.

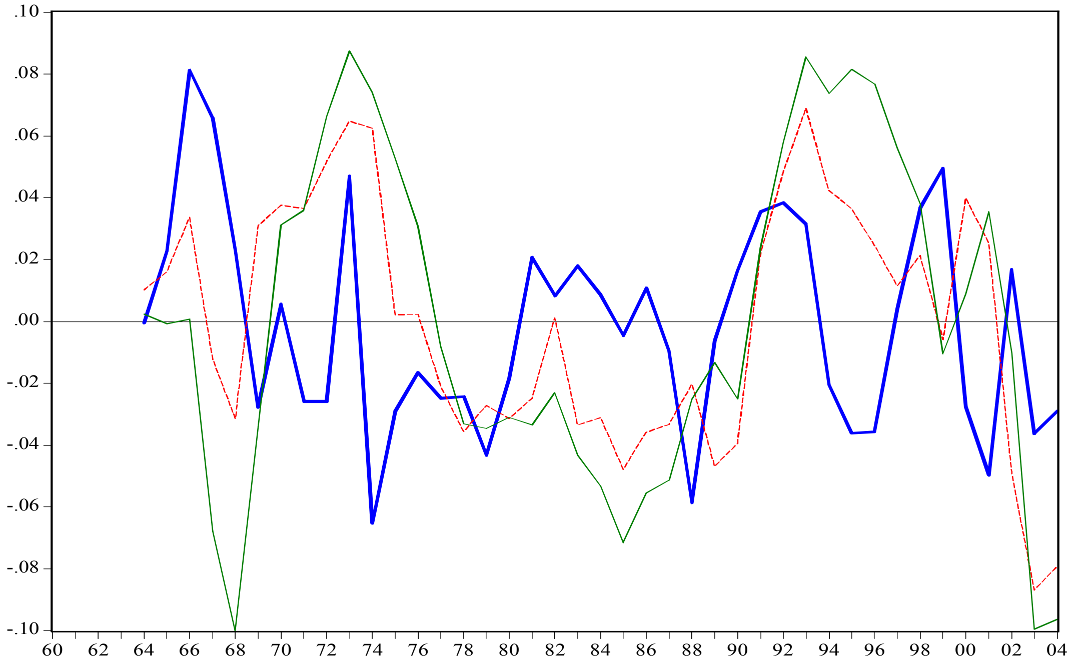
Main cointegrating vectors: Deviation from Long-Run Equilibrium

Figure 5 illustrates the cointegrating vectors in the three cases discussed above: the trade-included specification (Model 1, table 4), the trade-excluded specification (model 1, table 5) and the bivariate specification of trade volume and GDP (model 5, table 4). For each point in time, the cointegrating vector graph shows the deviation from the long-run equilibrium. It is calculated as:

$$\varepsilon_t = \ln Y_t - \ln C_t - \alpha \ln K_t - \beta \ln L_t - \gamma \ln H_t - \delta \ln T_t .$$

The figure shows that the trade-included model is less volatile than the trade-excluded one. Therefore, the errors' standard deviation of the former model is 27 percent less than of the latter (Table 4, appendix 3). This result is unsurprising given that the bivariate trade-GDP system is considerably more stable around its long-term equilibrium. Therefore, including trade in my specification has a significant effect on the residuals, thus confirming its role in explaining the evolution of GDP.

Figure 5: cointegrating vectors



Thick line- bivariate model; thin line- trade-excluded model; dashed line- trade-included model.

7.2.1.1 Robustness checks

This section checks whether previous trade-GDP associations are affected either by including further variables or by changing the pattern of the specifications (e.g., normalizing the variables by the number of labor hours). The only trade measure used here is the trade volume (TV).

From table 5 of appendix 3 we learn that adding fiscal variables (total government expenditure (G), total government expenditure as a share of GDP (GY) and total taxes as share of GDP (TAXY)) do not change the conclusion that trade and GDP are positively related in the long-run. The coefficients of the fiscal policy indicators show that higher expenditures are positively correlated with output, whereas a higher taxes-GDP ratio has an adverse effect.

The use of the human capital-labor force interaction (HL) yields similar results (Table 1, appendix 3). The coefficient of trade remains around 0.30, while the interaction variable has a coefficient between 0.25 and 0.30, very close to previous estimates. Note that excluding trade does *not* change this estimate (model 1), and has a sizeable effect only on the coefficient of K. In addition, its absence reduces the magnitude of the ECT, therefore making the return time to equilibrium longer.

Finally, normalizing the main variables by the number of labor hours gives similar qualitative results (Table 6, appendix 3). The GDP per labor hour (GDPPL) is positively correlated with trade per worker (TPL) and other variables. In general, the trade's coefficient is lower than in the above estimation, although it is usually above 0.23. In this case also, the coefficient of physical capital is accordingly higher. Human capital and total government expenditure both have positive associations with GDP.

7.2.2 Trade and Total Factor Productivity

The Johansen cointegration tests for TFP and other variables reported in table 6 indicate one cointegration vector in each case. Consistent with the endogenous growth theory, trade is positively correlated with TFP. This result is robust both to the trade measure adopted and to the inclusion of the human capital index (Table 7). To capture the structural break at 1993, a dummy variable has been added as an exogenous variable.

Table 6: Johansen cointegration tests results.

M	Max-Eigenvalue Test				Trace Test			
	H_0	H_1	*Statistic*	*Critical Value* ($\alpha = 5\%$)	H_0	H_1	*Statistic*	*Critical Value* ($\alpha = 5\%$)
1	r=0 *	r=1	37.60	14.26	r=0 *	$r\leq 1$	40.59	15.50
	r=1	r=2	2.98	3.84	$r\leq 1$	$r\leq 2$	2.98	3.84
2	r=0 *	r=1	25.31	14.26	r=0 *	$r\leq 1$	27.36	15.50
	r=1	r=2	2.06	3.84	$r\leq 1$	$r\leq 2$	2.06	3.84
3	r=0 *	r=1	21.47	14.26	r=0 *	$r\leq 1$	21.63	15.50
	r=1	r=2	0.16	3.84	$r\leq 1$	$r\leq 2$	0.16	3.84
4	r=0 *	r=1	41.18	14.26	r=0 *	$r\leq 1$	43.76	15.50
	r=1	r=2	2.59	3.84	$r\leq 1$	$r\leq 2$	2.59	3.84
5	r=0 *	r=1	40.55	21.13	r=0 *	$r\leq 1$	54.97	29.80
	r=1	r=2	11.42	14.26	$r\leq 1$	$r\leq 2$	14.42	15.50
6	r=0 *	r=1	29.56	21.13	r=0 *	$r\leq 1$	40.05	29.80
	r=1	r=2	8.49	14.26	$r\leq 1$	$r\leq 2$	10.49	15.50
7	r=0 *	r=1	44.58	21.13	r=0 *	$r\leq 1$	54.52	29.80
	r=1	r=2	6.54	14.26	$r\leq 1$	$r\leq 2$	9.93	15.50
8	r=0 *	r=1	41.35	21.13	r=0 *	$r\leq 1$	53.94	29.80
	r=1	r=2	9.65	14.26	$r\leq 1$	$r\leq 2$	12.59	15.50

Notes: * denotes rejection of the hypothesis at the 5% level. The critical values are from Haug, Mackinnon and Michelis (1999). The corresponding vectors are presented in table 7.

Including other determinants of TFP does not alter the conclusion of positive long-run trade-TFP association (Table 8). The last two models of table 8 are of special interest. In column 8, trade volume is included with the U.S. TFP in order to check for the result obtained when this exogenous measure is included. The result shows that the trade coefficient stays positive.[36] Therefore, the influence of foreign technological change on domestic productivity highlighted in previous studies embodies some true trade-TFP relationships. This is mainly because, for a domestic economy, trade is one central mechanism for the diffusion of foreign innovations.[37] The last model shows that the spillover of U.S. technological knowledge to Israel is larger the higher the Israeli imports from the U.S. as share of overall Israeli imports. This finding is in line with Coe and Helpman (1995).

Table 7: Cointegration Vectors of various variables with TFP.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
H					0.139	0.415	0.873	0.178
TV	0.306				0.266			
TVY		1.102				0.747		
TVWT			1.413				0.674	
TVPC				0.490				0.402
Const.	2.337	10.692	17.876	5.114	3.449	10.803	14.441	6.141

Notes: All variables are in natural logarithms. Dependent Variable: Natural Logarithm of TFP.

The signs of other variables are, in general, as expected (columns 1-7, Table 8). Higher standard deviation of inflation and higher deficit as share of GDP are both negatively correlated with TFP. In contrast, road capital, government expenditure and taxes are positively cointegrated with TFP. The result about taxes is opposite to earlier expectations that consider higher taxes as harmful for efficiency and therefore for productivity. This surprising result may be biased by the volatility of this variable on one side and by its role in financing government actions, on the other.

Finally, decomposing trade into exports and imports shows that they are both cointegrated with TFP (Tables 7-10, appendix 3).

[36] In a broader model that includes TV, H, G, STDINF and USTFP, the sign of this measure turns to be negative.

[37] In other words, for a foreign influence on domestic TFP to occur, some spillover channel is needed. A lack of such a channel makes this spillover minor or even unfeasible. Since the Israeli capital-openness is a newer 'phenomenon', trade seems to be the main channel for this diffusion.

Table 8: Cointegration Vectors of various variables with TFP.

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
H	0.566	0.500	0.507	0.633	0.428	0.331	0.500	0.777	0.494
TV	0.085	0.203	0.121	0.143	0.230	0.288	0.131	0.338	
G	0.143						0.114		0.314
GY		0.301							
TAXY			0.254						
DEFY				-0.524					
STDINF					-0.042		-0.010		-0.020
KROAD						0.051			
Const.	4.787	5.185	7.669	6.903	4.591	1.456	4.288	2.068	2.238
USTFP* [38] OPENMUS									0.247

Notes: All variable, except of DEFY and STDINF, are in natural logarithms. Dependent Variable: Natural Logarithm of TFP.

[38] Since USTFP is an exogenous variable it is not a part of the cointegration vector (It only influences the relationship exogenously without being a part of). Therefore, the USTFP is not shown in model 8. However, since in model 9 USTFP is multiplied by OPENMUS (which is endogenous), the outcome is endogenous either. Consequently, its coefficient is reported above.

7.4 Vector Error Correction Models and Granger Causality Tests

Since in almost all cases cointegration has been detected between both GDP and TFP on one side and trade measures on the other, VECM-based causality tests are carried out. This subsection presents only these parts of VECM models which are relevant for the current study. Causalities from other variables (e.g., labor, capital) to GDP or TFP are not reported in the tables below.

7.4.1 Trade and Output

The causality tests reported in table 9 show that, in general, trade does Granger-cause output (causality has been found in 6 out of 8 cases). The only two cases where such causality is unestablished are the multivariate models with TVY and TVWT. As for the first measure, this result is probably biased by the different problems discussed before.[39] The result for the TVWT may be surprising, although its evolution is hardly affected by the Israeli trade, so that any effect trade may truly have on output is unobserved here. Specifically, if the rapid growth of the Israeli trade is unassociated with a higher share of overall world trade, then the causal link is subject to bias. Besides, note that the two variables have the expected signs and they are not far from being significant at the 10 percent level.

A very notable result is the positive sign of the error-correction term.[40] Usually, for a gradual return to equilibrium, this ECT should be negative and less than one in absolute value (i.e., between -1 and 0). The opposite sign found here is possibly biased by the omission of other variables or due to a big shock to some of the explanatory variables, thus taking the system further away of its long-run equilibrium. The cointegration graphs presented before show a large deviation from long-term equilibrium following the mass migration. Therefore, one possible omitted variable is the 'stock' of immigrants in Israel. Adding this variable yields significant negative ECT almost in all cases without altering the positive trade-GDP long-run association or the trade-to-output causality (tables 14 through 16, appendix 4).[41]

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[39] As previously discussed, another reason for the unclear effect of this variable on GDP or TFP is its volatility. Taking its four-period moving average shows that causality runs from this variable to GDP (t statistic of 1.96).

[40] In the first model (multivariate with TV), the coefficient of the ECT(-1) seems larger than 1. However, a formal test shows that it is statistically less than 1.

[41] Considering the effect of this variable follows comments by Michel Strawczynski. I am grateful to him.

Causality has been robustly detected form the trade volume per capita (TVPC) to output per capita (GDPPC), in both bivariate and multivariate models. This conclusion holds also in the bivariate models of GDPPC and the other trade measures previously discussed.

Moreover, to ensure that the results here are unaffected by the fact that trade is itself a component of output (via the national accounting identity), a causality test is processed from the trade volume (TV) to the net-of-trade GDP. In other words, I test for influence for TV on the sum of government expenditure, private consumption and investments. This test is in line with several studies that discuss this endogeneity (e.g., Feder, 1983; Ghatak *et al.*, 1997; Herzer *et al.*, 2004). The results show that output is positively caused by trade both in the bivariate and multivariate models. Cointegration, however, has been observed only in the first case. Therefore, in the bivariate model, a standard causality test has been employed.

Finally, considering the alternative human capital measure (YS13) even strengthen the above findings: with the exception of TVWT as trade measure, causalities have been observed in the whole other multivariate specifications (table 4 in Appendix 4).

Table 9: Granger Causality Tests, GDP and Trade measures

The trade measure	**Independent Variables**			
	ECT(-1)	**D(trade(-1))**	**D(trade(-2))**	**D(trade(-3))**
TV	1.284 * (2.58)	0.092 (0.73)	0.279 *** (1.65)	0.130 (1.00)
TVY	0.843 * (2.43)	0.088 (0.67)	0.264 (1.55)	0.134 (0.87)
TVWT	0.631 *** (1.90)	0.147 (1.58)	-0.016 (-0.14)	0.125 (1.23)
TVPC	0.900 * (2.40)	0.257 * (2.42)	-0.066 (-0.63)	0.150 (1.32)
TV	0.502 * (3.25)	0.205 ** (2.28)		
TVY	0.147 * (2.86)	0.206 (1.42)	0.232 *** (1.77)	0.139 (1.14)
TVWT	0.063 ** (2.21)	0.302 * (3.10)	0.123 (1.31)	0.097 (1.18)
TVPC	0.140 * (2.85)	0.310 * (3.74)		

Notes: these causality tests are based on the vector error-correction models formulated from the cointegration tests in table 3. * Significant at the 1% level. ** Significant at the 5% level. *** Significant at the 10% level.

7.4.2 Trade and Total Factor Productivity

The TFP has been found to be positively caused by trade in half of the cases. The results show that neither TVWT nor TVY Granger-causes productivity. However, testing for causality for the pre-1994 period shows that TVY does cause TFP. Such causality has been also detected when taking both the trend and the moving average of this volatile measure. Therefore, it seems that both the structural break in 1994 and the volatility of this measure make the causality from this variable to output unrobust. In addition, based on the cointegration vectors reported in table 8, TFP has been found to be Granger-caused by the trade volume (TV) in all cases (Table 1, Appendix 4). Finally, rerunning the first four specification using the YS13 measure does not alter the conclusion of positive causality from trade to GDP (table 5, Appendix 4).

Table 10: Granger Causality Tests, TFP and Trade measures

The trade measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
TV	-0.286 * (-6.05)	0.109 * (2.26)	
TVY	-0.212 * (-4.48)	-0.023 (-0.32)	
TVWT	-0.088 * (-2.39)	-0.068 (-1.18)	
TVPC	-0.267 * (-5.55)	0.094 *** (1.91)	
TV	-0.309 * (-6.24)	0.119 * (2.33)	-0.018 (-0.34)
TVY	-0.262 * (-5.196)	0.018 (0.26)	
TVWT	-0.292 * (-5.75)	-0.072 (-1.50)	
TVPC	-0.304 * (-5.95)	0.091 *** (1.75)	

Notes: these causality tests are based on the vector error-correction models formulated from the cointegration tests in table 6. *, **, ***- as in table 10.

In contrast to GDP, in all cases the ECT is in its expected (negative) range, suggesting a gradual return to long-term equilibrium. Since TFP measures output net of capital and labor, its calculation embodies the strong impact of migration on these inputs. Hence, the negative coefficient found here supports the prediction that the mass migration of early 1990s has, via its influence on the labor force and investments[42], a sizeable influence on the long-run stability.

[42] Refer to Lavi and Strawczynski (2001) for a detailed discussion on the positive effects of immigration on production inputs.

7.5 Decomposing Trade: Exports, Imports and Economic Growth

7.5.1 Exports, Imports and output

In this subsection, the above causality tests are processed using separate measures for exports and imports. Table 11 shows that in 7 out of 8 cases, exports cause output, while table 12 reports causality from imports to GDP in all cases. Therefore, the trade-GDP causalities found before resulted from both exports and imports.[43] Moreover, the per capita GDP has been found to be Granger-caused by the per capita of both exports and imports, whereas the net-of-trade output is positively and significantly caused only by exports.

Table 11: Granger Causality Tests, GDP and Exports measures

The exports measure	**Independent Variables**			
	ECT(-1)	**D(trade(-1))**	**D(trade(-2))**	**D(trade(-3))**
EX +	0.678 ** (2.19)	0.199 *** (1.77)	0.064 (0.60)	0.103 (1.01)
EXY +	0.570 ** (2.19)	0.199 *** (1.77)	0.064 (0.60)	0.103 (1.01)
EXWM	0.820 * (3.24)	0.100 *** (1.72)	-0.077 (-1.09)	0.052 (0.76)
EXPC	0.589 ** (2.16)	0.208 *** (1.79)	0.101 (0.98)	0.117 (1.18)
EX	0.022 * (0.21)	0.164 ** (2.07)		
EXY	0.018 * (0.49)	0.165 * (2.03)	0.037 (0.41)	
EXWM	-0.064 * (-2.64)	-0.013 (-0.18)		
EXPC	-0.271 * (-3.16)	0.153 * (2.55)		

Notes: these causality tests are based on the vector error-correction models formulated from the cointegration tests in table 5, appendix 3. *, **, ***- as in table 10.
+ The values in these two rows seem similar due to rounding up.

[43] Similarly to the case of TV, adding the share of immigrants of Israeli population yields significant negative ECTs, without affecting the positive influence exports and imports have on GDP.

7.5.2 Exports, Imports and TFP

The causality tests results show that the Israeli TFP is driven by exports, whereas imports seem as having no influence over it (tables 13 and 14). In particular, causality runs from exports to TFP in 5 cases whereas no imports-to-TFP causality has been detected. For the bivariate model with EXY, causality has been found for the period 1960-1993 and for both the trend and the moving average of this variable. Moreover, the causality tests presented in tables 2 and 3 of appendix 4 confirm this conclusion since adding more variables do not alter the significant influence of exports or the insignificance of imports. Similarly to the case of total trade, the ECTs have significant negative coefficients for both exports and imports.

Replacing the enrollment ratio by the share of population with 13 schooling years or more yields similar results: In the models of TFP, human capital and trade measures, only exports have been found as causing TFP (tables 6 and 7, appendix 4). These results confirm once again that the principal findings of this study are unbiased by the measurement of human capital.

Table 12: Granger Causality Tests, GDP and Import measures

The imports measure	Independent Variables				
	ECT(-1)	**D(trade(-1))**	**D(trade(-2))**	**D(trade(-3))**	**D(trade(-4))**
IM	0.361 * (2.45)	0.177 ** (2.22)	-0.217 (-1.48)	0.043 (0.45)	
IMY	1.163 * (2.45)	0.177 ** (2.22)	-0.127 (-1.48)	0.043 (0.45)	
IMWX	0.720 * (2.25)	0.114 *** (1.84)	-0.040 (-0.54)	0.068 (0.97)	
IMPC	1.226 * (2.96)	0.169 ** (2.25)	-0.127 (-1.58)	0.071 (0.79)	
IM	0.253 * (1.89)	0.317 * (3.05)	0.086 (0.85)	0.121 (1.40)	0.086 (1.08)
IMY	0.048 *** (1.89)	0.317 * (3.05)	0.086 (0.85)	0.121 (1.40)	
IMWX	–	0.072 *** (1.65)			
IMPC	0.075 *** (1.91)	0.213 * (2.96)	-0.002 (-0.02)		

Notes: these causality tests are based on the vector error-correction models formulated from the cointegration tests in table 6, appendix 3. *, **, ***- as in table 10.

Table 13: Granger Causality Tests, TFP and Export measures

The exports measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
EX	-0.250 * (-6.06)	0.125 * (2.85)	0.00 (0.01)
EXY	-0.181 * (-4.81)	0.034 (0.55)	
EXWM	-0.194 * (-5.78)	-0.060 (-1.14)	
EXPC	-0.245 * (-5.84)	0.116 * (2.61)	
EX	-0.276 * (-6.13)	0.135 * (3.00)	0.007 (0.13)
EXY	-0.343 * (-5.87)	0.104 *** (1.80)	-0.012 (-0.20)
EXWM	-0.201 * (-7.22)	-0.049 (-1.01)	
EXPC	-0.276 * (-6.13)	0.135 * (3.00)	0.007 (0.13)

Notes: these causality tests are based on the vector error-correction models formulated from the cointegration tests in table 10, appendix 3. *, **, ***- as in table 10.

Table 14: Granger Causality Tests, TFP and Import measures

The imports measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
IM	-0.292 * (-5.52)	0.030 (0.74)	
IMY	-0.112 * (-2.39)	-0.067 (-1.02)	
IMWX	–	0.011 (0.26)	
IMPC	-0.292 * (-5.53)	0.03 (0.74)	
IM	-0.314 * (-5.77)	0.032 (0.74)	-0.038 (-0.91)
IMY	-0.251 * (-4.16)	-0.062 (-1.12)	
IMWX	-0.311 * (-5.61)	-0.017 (-0.54)	
IMPC	-0.314 * (-5.77)	0.032 (0.74)	-0.038 (-0.91)

Notes: these causality tests are based on the vector error-correction models formulated from the cointegration tests in table 11, appendix 3. . *, **, ***- as in table 10.

7.5.3 On the Imports-GDP Causality: Is it Physical Capital Accumulation?

The surprising lack of imports impact on TFP raises questions about the channel through which output is caused by imports. One possible channel is the influence of imports on physical capital accumulation that has been discussed in literature. Wacziarg (1998) argues that trade may provide a 'big push' effect on physical capital accumulation. He suggests three possible ways for this channel to operate. *First*, trade liberalization enables domestic agents to import unavailable capital goods (or produced at home but with higher costs). The imports of capital goods reduce the constraints on investment, and allow new technologies to 'cross the border', thus enhancing the process of capital accumulation. *Second*, open countries are better able to exploit increasing returns to scale, which operate by expanding the extents of markets (Ades and Glaeser, 1994). Market sizes increase the rate of capital accumulation, consequently supporting growth. The *third* channel usually applies to relatively labor-abundant economies. When adopting free-trade policies, they experience an increase in wages and decrease in the prices of investment goods as a part of factor price equalization. The decrease in investment prices leads to higher investments and more physical capital.

Levine and Renelt (1992), Baldwin and Seghezza (1996) Wacziarg and Welch (2003), Giavazzi and Tabellini (2004) and Grier (2005) are among the scholars who support the positive effect of trade on physical capital accumulation. Romer (1990b) shows that a higher imports-GDP ratio is associated with higher physical investment. The positive effect of trade[44] on capital accumulation in Levine and Renelt (1992) is one of only two robust results in their sensitivity analysis. The second robust result is the positive effect of the investment-GDP ratio on growth. Therefore, they conclude that the positive effect trade has on output growth "may be based on enhanced resource accumulation and not necessarily on the improved allocation of resources". This result is somehow surprising for those authors since as previously discussed, the theoretical trade-growth relationships seem to run through productivity rather than higher physical capital investments.

[44] The results they obtained using the exports-GDP ratio and the imports-GDP ratio were identical.

Following these voluminous studies, I carry out imports-physical capital cointegration and causality tests. The cointegration vectors are presented in table 12 of appendix 3, where the causality tests are reported in table 15 below. The cointegration tests suggest a robust positive imports-physical capital association. Based on these specifications, the Granger causality tests are, in general, supportive of the prediction that capital accumulation is enhanced by imports: Causality has been detected in 7 out of 12 cases, whereas in the other 5 cases it has been rejected (models 2 and 8-11). As for model 2, causality has not been approved possibly due to the problems of this measure mentioned earlier.[45] Each of the models 8 through 11 contains some variable that has been very unstable during the sample period. Therefore, the results found here may have been biased by the volatility of each of these variables.

These results may reflect the contribution of imports to Israeli economic development through the accumulation of inputs. This finding seems reasonable since most of the Israeli imports are production inputs and investment goods rather than consumer goods. However, the results should also be taken carefully since they do not necessarily mean that greater imports lead to more physical capital. Physical capital increases as agents wish to invest more. Higher desired capital makes higher imports and thereby increases the capital stock. In other words, this causality may show that the developments in imports operate as leading indicator for future physical capital evolution rather than economically causing it.

[45] The causality test using the trend of this measure indicates a significant positive causality.

Table 15: Granger Causality Tests, K and Import measures

The Imports measure	ECT(-1)	Independent Variables D(trade(-1))
IM	-0.059 * (-3.94)	0.044 * (2.63)
IMY	-0.025 * (-3.80)	0.019 (0.79)
IMWX	–	0.065 * (5.26)
IMPC [46]	-0.059 * (-3.94)	0.317 *** (1.89)
IM	-0.044 * (-3.36)	0.051 * (2.85)
IM	-0.081 * (-5.23)	0.036 *** (1.86)
IM	-0.085 * (-5.06)	0.032 *** (1.86)
IM	-0.086 * (-4.25)	0.009 (0.46)
IM	-0.075 * (-5.27)	0.022 (1.28)
IM	-0.075 * (-4.60)	0.018 (0.93)
IM	-0.080 * (-5.34)	0.017 (1.00)
IM	-0.013 ** (-2.04)	0.045 * (2.39)

*Note*s: these causality tests are based on the vector error-correction models formulated from the cointegration tests in table 15, appendix 3. . *, **, ***- as in table 10.

[46] A similar result has been observed when the capital stock (K) was replaced by the per capita capital (KPC).

7.6 Reverse Causation

Since theory also suggests an influence of economic growth on trade, reverse causality tests are briefly presented here. Causality has been detected form GDP to exports in half of the cases, although with unstable direction of causation. Whereas the real value of exports (EX) has been positively affected by output, the exports-GDP ratio (EXY) has been negatively caused.[47] The Error-Correction Term of the exports equation has been significant in 7 out of the 8 cases considered. Contrarily, exports have been affected by the evolution of TFP in none of the examined cases. The last result indicates that, in the long run, productivity adjusts to short run shocks in exports whereas a reverse adjustment does not occur.

The results regarding imports differ considerably. Whereas none output to imports causality has been found, imports have been affected by the evolution of TFP in 6 out of 8 cases.[48] One possible explanation for this result is that an increase in productivity is a signal of economic expansion, thus leading to higher imports. Finally, this finding seems as more valid for the short-run, since the Error-Correction Term has been significant in only 2 cases.

7.7 The Total Factor Productivity in the Manufacturing Sector:

As previously noted, since 1994 there has been a substantial decline in the Israeli TFP, which possibly affected some of the previous results. To ensure the conclusion of positive effects of trade (and more precisely exports) on productivity, some of the previous cointegration and causality tests have been employed using the productivity of the Israeli manufacturing sector.[49] Two key reasons for using this variable: first, the data on the Israeli manufacturing sector are of high quality and reliability. Second, this variable has not been declining in the early 1990's, but rather continues to grow as before (figure 2, appendix 5). The absence of a structural break in this variable helps to have a more reliable conclusion regarding the role of trade in the productivity growth.

Tables 8 to 13 of appendix 4 report the results of running this measure (named TFPM) on trade (and its two components) and a human capital measure (either H or YS13). The results are straightforward with previous ones: exports are productivity-

[47] This result may be unsurprising since higher output, other things equal, is associated with a lower export share of GDP.

[48] No robust causality has been found from TFP to the trade volume.

[49] Data are available for the period 1969-2004 only.

promoting while imports seem as having no influence on productivity. In addition, almost in all cases, cointegration has been observed (the results are unreported here).

8. Concluding Remarks

This paper examines the impact of international trade on Israeli economic growth over the period 1960-2004. Despite a strong belief that trade (particularly exports) is an engine for sustainable Israeli economic growth, former empirical studies were inconclusive regarding the validity of this prediction.

To test for this nexus, cointegration and causality tests were processed. The cointegration tests indicate positive long-run relationships between exports and imports from one side, and output and TFP from the other. These results are robust both to the four trade measure utilized here and to changes in the patterns of specifications.

The causality tests show that output is enhanced by both exports and imports. Total factor productivity, however, is caused only by exports suggesting that the Israeli economy is export-led through productivity. As for imports, the study finds some evidence regarding a positive effect on the accumulation of physical capital. Although this channel has been highlighted by several studies, it is indecisive whether this causality necessarily reflects a true economic effect. It may show that developments in imports indicate future evolutions of physical capital, mainly due to increase in the imports of capital goods that, by themselves, are growth-promoting.

Although this study provides evidence about the significant role of exports in macro-level growth, it does not point to the economic sectors that have been either benefited from or were harmed by the Israeli integration in international markets. Therefore, a future research that copes with this issue may possibly be complementary to the current one. Such a study is of high importance since it helps to identify the accurate trade policy needed to support economic growth on one side, and on the other to ensure the survival of some import-threatened economic fields.

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Appendices:

Appendix 1: Data Summary

GDP: Gross Domestic Product in real terms.

GDPPC: Gross Domestic Product per capita in real terms.

NGDP: The net-of-Trade Gross Domestic Product in real terms.

TFP: The Israeli Total Factor Productivity.

TFPM: The Total Factor Productivity of the manufacturing sector.

TV: The trade volume (exports plus imports) in real terms.

TVY: The trade volume-GDP ratio.

TVWT: The trade volume as a share of world trade.

TVPC: The trade volume per capita.

EX: Exports in real terms.

EXY: The exports-GDP ratio.

EXWM: Exports as a share of world imports.

EXPC: Exports per capita.

IM: Imports in real terms.

IMY: The imports-GDP ratio.

IMWX: Imports as a share of world exports.

IMPC: Imports per capita.

OPENMUS: the share of Israeli imports from the U.S. to overall Israeli imports.

K: Gross capital stock, in real terms.

L: The weekly number of labor hours.

H: A human capital index, measured as the enrollment rate at secondary school (the ratio of pupils in secondary school to the number of people in the age group 15-18 years).

SY13: the share of the Israeli population with 13 schooling years or more.

G: Total government expenditures, in real terms.

GY: The government size (the ratio of total government expenditures to GDP).

TAXY: Taxes as a share of GDP.

DEFY: The government budget deficit to GDP.

KROAD: Roads capital stock.

USTFP: The U.S. Total Factor Productivity, calculated with a labor share of 2/3 and capital share of 1/3.

STDINF: the 5-year moving average of the Standard deviation of inflation.

GDPPL: Gross Domestic Product per labor hour.

KPL: Gross capital stock per labor hour.

HPL: the human capital index normalized to the number of labor hours.

TVPL: The trade volume per labor hour.

GPL: Total government expenditure normalized to the number of labor hours.

R: The real interest rate (calculated as the nominal Over-drawn current account interest rate net of ex-post inflation).

IMM: The number of immigrants to Israel.

IMMS: The 'stock' of immigrants in Israel.

Appendix 2: Unit Root Tests

Table 1: ADF unit root tests, 1960-2004

	level			First Difference		
	statistic	*Critical (5%)*	*Critical (10%)*	*statistic*	*Critical (5%)*	*Critical (10%)*
GDPPC	-1.96	-3.51	-3.19	-1.98	-1.95	-1.61
NGDP	-2.00	-3.51	-3.19	-3.01	-1.95	-1.61
TFPM	-2.77	-3.54	-3.20	-5.46	-1.95	-1.61
SY13	-1.58	-3.52	-3.19	-7.25	-1.95	-1.61
G	-2.00	-3.51	-3.19	-1.83	-1.95	-1.61
GY	-2.03	-3.51	-3.19	-7.70	-1.95	-1.61
TAXY	-1.55	-3.52	-3.19	-6.79	-1.95	-1.61
DEFY	-2.51	-3.52	-3.19	-6.47	-1.95	-1.61
STDINF	-2.36	-3.51	-3.19	-5.25	-1.95	-1.61
KROAD	-2.88	-3.52	-3.19	-1.92	-1.95	-1.61
USTFP	-2.98	-3.53	-3.20	-3.24	-1.95	-1.61
IMM	-2.54	-3.54	-3.20	-5.14	-1.95	-1.61
IMMS	-2.61	-3.54	-3.21	-5.54	-1.95	-1.61
GDPPL	-0.64	-3.52	-3.19	-1.94	-1.95	-1.61
KPL	-2.53	-3.52	-3.19	-2.62	-1.95	-1.61
HPL	-1.33	-3.52	-3.19	-5.72	-1.95	-1.61
TVPL	-2.39	-3.52	-3.19	-3.99	-1.95	-1.61
GPL	-1.87	-3.52	-3.19	-6.44	-1.95	-1.61
R	-2.07	-3.52	-3.19	-8.30	-1.95	-1.61

Appendix 3: Cointegration Vectors

Table 1: Cointegration Vectors of various variables with output.

Variable	1	2	3	4	5	6
K	0.703	0.331	0.321	0.330	0.296	0.479
HL	0.252	0.250	0.242	0.256	0.234	0.106
TV		0.317	0.317	0.318	0.352	0.285
G			0.022			
GY				0.062		
TAXY					0.009	
STDINF						0.023
Const.	4.943	6.730	6.519	6.637	6.913	5.070

All variables, except of STDINF, are in natural logarithms. Dependent Variable: Natural Logarithm of GDP.

Table 2: Cointegration Vectors of various variables with output.

Var.	1	2	3	4	5	6	7	8
K	0.580	0.689	0.617	0.514				
L	0.133	0.159	0.372	0.194				
H	0.214	0.254	0.126	0.260				
EX	0.159				0.702			
EXY		0.190				2.405		
EXWT			0.149				2.224	
EXPC				0.273				0.707
Const.	7.731	6.576	6.623	8.002	18.442	29.415	39.926	18.614

All variables are in natural logarithms. Dependent Variable: Natural Logarithm of GDP.

Table 3: Cointegration Vectors of various variables with output.

Var.	1	2	3	4	5	6	7	8
K	0.546	0.640	0.583	0.595				
L	0.205	0.240	0.431	0.261				
H	0.498	0.583	0.285	0.295				
IM	0.146				0.812			
IMY		0.171				4.320		
IMWX			0.155				—	
IMPC				0.154				1.428
Const.	8.128	7.157	7.045	6.223	16.942	30.447	—	12.088

All variables are in natural logarithms. Dependent Variable: Natural Logarithm of GDP.

Table 4: Standard deviations test

F statistic		1.86
F critical:	α =10%	1.51
	α =5%	1.69
	α =1%	2.11

Table 5: Cointegration Vectors of various variables with output.

Variable	1	2	3	4	5
K	0.381	0.363	0.252	0.306	0.536
L	0.222	0.258	0.032	0.105	0.152
H	0.248	0.256	0.286		0.075
TV	0.276	0.286	0.492	0.493	0.223
G	0.018				
GY		0.060			
TAXY			-0.011	-0.307	
STDINF					0.021
Const.	6.294	6.539	6.703	5.329	4.609

All variables are in natural logarithms. Dependent Variable: Natural Logarithm of GDP.

Table 6: Cointegration Vectors of various variables with output per labor hour.

Variable	1	2
KPL	0.500	0.450
HPL	0.169	0.296
TVPL	0.231	0.314
GPL		0.046
Const.	5.280	6.978

Notes: All variables are in natural logarithms.
Dependent Variable: Natural Logarithm of GDP Per worker.

Table 7: Cointegration Vectors of exports measures and human capital with TFP.

	1	2	3	4	5	6	7	8
H					0.246	0.737	0.178	0.246
EX	0.280				0.233			
EXY		0.718				0.171		
EXWM			0.861				0.875	
EXPC				0.276				0.233
Const.	7.117	11.151	15.157	7.274	7.804	10.893	15.371	7.898

Notes: All variables are in natural logarithms. Dependent Variable: Natural Logarithm of TFP.

Table 8: Cointegration Vectors of imports measures and human capital with TFP.

	1	2	3	4	5	6	7	8
H					0.166	0.741	1.301	0.166
IM	0.317				0.225			
IMY		1.414				0.687		
IMWX			_				0.223	
IMPC				0.317				0.265
Const.	6.596	11.584	_	6.724	7.292	11.358	12.211	7.399

Notes: All variables are in natural logarithms Dependent Variable: Natural Logarithm of TFP.

Table 9: Cointegration Vectors of various variables with TFP.

Variable	1	2	3	4	5	6	7	8
H	0.550	0.620	0.353	1.046	0.546	0.495	0.451	0.849
EX	0.114	0.174	0.198	0.084	0.191	0.104	0.139	0.350
G	0.129						0.203	
GY		0.113						
TAXY			0.047					
DEFY				-0.543				
STDINF					-0.059		-0.012	
KROAD						0.255		
Const.	6.064	8.798	8.296	9.943	8.480	1.529	3.872	6.959

Notes: All variables, except of STDINF and DEF, are in natural logarithms. Dependent Variable: Natural Logarithm of TFP.

Table 10: Cointegration Vectors of various variables with TFP.

Variable	1	2	3	4	5	6	7	8
H	0.594	0.549	0.182	0.516	0.353	0.402	0.476	0.100
IM	0.044	0.194	0.248	0.174	0.251	0.211	0.147	0.288
G	0.187						0.182	
GY		0.142						
TAXY			0.097					
DEFY				-0.433				
STDINF					-0.034			
KROAD						0.153	-0.001	
Const.	5.367	8.479	7.596	8.535	8.480	3.359	4.274	6.991

All variables, except of STDINF and DEF, are in natural logarithms. Dependent Variable: Natural Logarithm of TFP.

Table 11: Cointegration Vectors of various variables with TFP (Trade is excluded)

Variable	1	2	3	4	5	6	7	8	9
H	1.217	0.741	1.355	1.040	1.175	1.626	0.481	0.948	0.771
G		0.204						0.175	0.065
GY			0.250						
TAXY				0.244					
DEFY					-0.735				
STDINF						-0.142		-0.045	-0.138
KROAD							0.298		
Const.	10.986	5.535	11.308	11.108	10.921	11.317	1.311	6.416	9.076

Notes: All variables, except of STDINF and DEF, are in natural logarithms. Dependent Variable: Natural Logarithm of TFP.

Table 12: Cointegration Vectors of imports measures with TFP.

	1	2	3	4	5	6	7
IM	0.854				0.633	0.989	0.837
IMY		3.667					
IMWX			-				
IMPC				0.854			
H					1.495		
G						-0.195	
GY							-0.172
Const.	16.825				20.345	20.207	16.853

Notes:All variables are in natural logarithms. Dependent Variable: Natural Logarithm of K.

Table 13: Cointegration Vectors of various variables with Physical Capital, continued.

	8	9	10	11	12
IM	0.898	0.896	0.890	0.930	0.570
TAXY	-0.239				
DEFY		0.186			
STDINF			-0.038		
R				0.078	
IMM					0.697
Const.	16.205	16.361	16.434	15.973	12.793

All variables, except of STDINF and DEFY are in natural logarithms.
Dependent Variable: Natural Logarithm of K.

Appendix 4: Causality Tests [50]

Table 1: Granger Causality Tests, TFP and Trade measures

Independent Variables		
ECT(-1)	**D(trade(-1))**	**D(trade(-2))**
-0.372 * (-5.21)	0.140 * (2.42)	-0.002 (-0.02)
-0.340 * (-6.10)	0.123 * (2.38)	
-0.370 * (-5.61)	0.145 * (2.53)	-0.019 (-0.31)
-0.358 * (-6.33)	0.137 * (2.76)	
-0.331 * (-6.33)	0.122 * (2.34)	-0.010 (-0.19)
-0.264 * (-6.83)	0.100 ** (2.25)	-0.053 (-1.16)
-0.351 * (-5.47)	0.132 * (2.19)	-0.006 (-0.09)
-0.369 * (-6.42)	0.118 *** (1.91)	
-0.266 * (-5.23)	-0.034 (-0.98)	

*Note*s: these causality tests are based on the vector error-correction models formulated from the cointegration tests of table 8. The trade measure: TV.

Table 2: Granger Causality Tests, TFP and Export measures

Independent Variables			
ECT(-1)	**D(trade(-1))**	**D(trade(-2))**	**D(trade(-3))**
-0.335 * (-6.06)	0.153 * (3.29)	0.049 (0.92)	
-0.338 * (-6.15)	0.154 * (3.30)	0.041 (0.77)	
-0.295 * (-6.03)	0.130 * (2.72)	0.001 (0.03)	
-0.380 * (-6.00)	0.206 * (4.64)	0.068 (1.27)	0.112 * (2.34)
-0.284 * (-6.25)	0.119 * (2.60)		
-0.227 * (-6.29)	0.027 (0.56)		
-0.270 * (-6.57)	0.111 * (2.45)		
-0.325 * (-4.67)	0.134 ** (2.06)	-0.052 (-0.79)	0.088 (1.30)

*Note*s: these causality tests are based on the vector error-correction models formulated from the cointegration tests of table 12 (App. 3). The exports measure: EX.

[50] In all the tables, *, ** and *** denote significance in the 1%, 5% and 10% level, respectively. all the causality tests are based on unreported vector error-correction models formulated from cointegration tests.

Table 3: Granger Causality Tests, TFP and Import measures

Independent Variables			
ECT(-1)	D(trade(-1))	D(trade(-2))	D(trade(-3))
-0.354 *	0.068		
(-5.73)	(1.37)		
-0.354 *	0.047		
(-5.73)	(1.07)		
-0.317 *	0.035		
(-5.41)	(0.81)		
-0.349 *	0.049		
(-5.77)	(1.20)		
-0.330 *	0.048	-0.020	0.034
(-4.78)	(0.87)	(-0.38)	(0.60)
-0.226 *	0.070 **		
(-7.86)	(2.15)		
-0.317 *	0.045		
(-7.11)	(1.09)		
-0.267 *	0.031		
(-4.25)	(0.72)		

*Note*s: these causality tests are based on the vector error-correction models formulated from the cointegration tests of table 13 (App. 3). The imports measure: IM.

Table 4: Granger Causality Tests, GDP and Trade measures

The trade measure	Independent Variables			
	ECT(-1)	D(trade(-1))	D(trade(-2))	D(trade(-3))
TV	0.926 *	0.475 *	0.012	0.213 ***
	(2.83)	(3.89)	(0.12)	(1.77)
TVY	0.446 **	0.439 *	0.035	0.205
	(2.01)	(3.10)	(0.29)	(1.51)
TVWT	-0.095	0.085		
	(-0.52)	(1.09)		
TVPC	0.798 *	0.448 *	0.232 ***	0.139
	(3.26)	(3.79)	(1.77)	(1.14)

Table 5: Granger Causality Tests, TFP and Trade measures

The trade measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
TV	-0.297 *	0.118 **	-0.023
	(-5.77)	(2.28)	(-0.46)
TVY	-0.271 *	0.060	-0.041
	(-5.20)	(0.86)	(-0.59)
TVWT	-0.337 *	0.010	0.005
	(-5.75)	(0.16)	(0.09)
TVPC	-0.290 *	0.111 **	-0.024
	(-5.47)	(2.05)	(-0.46)

Table 6: Granger Causality Tests, TFP and Export measures

The exports measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
EX	-0.286 * (-5.89)	0.159 * (3.52)	0.005 (0.11)
EXY	-0.266 * (-5.29)	0.160 * (2.69)	-0.012 (-0.20)
EXWM	-0.248 * (-4.66)	-0.057 (-0.91)	0.057 (0.86)
EXPC	-0.286 * (-5.89)	0.159 * (3.52)	0.005 (0.11)

Table 7: Granger Causality Tests, TFP and Import measures

The imports measure	Independent Variables			
	ECT(-1)	D(trade(-1))	D(trade(-2))	D(trade(-3))
IM	-0.288 * (-5.20)	0.040 (0.88)	-0.028 (-0.66)	
IMY	-0.270 * (-4.66)	-0.025 (-0.45)	-0.051 (-0.97)	
IMWX	-0.261 * (-4.44)	-0.018 (-0.49)		
IMPC	-0.325 * (-4.78)	0.095 *** (1.71)	-0.007 (-0.15)	0.033 (0.68)

Table 8: Granger Causality Tests, TFPM and Trade measures

The trade measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
TV	-0.716 * (-2.77)	0.061 (0.73)	
TVY	-0.215 (-0.87)	-0.051 (-0.36)	-0.208 (-1.57)
TVWT	-0.155 *** (-1.66)	0.075 (0.73)	-0.047 (-0.45)
TVPC	-0.411 (-1.62)	0.053 (0.56)	

Note: human capital measure-enrollment ratio (H).

Table 9: Granger Causality Tests, TFPM and Export measures

The exports measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
EX	-0.455 * (-3.11)	0.172 * (2.61)	
EXY	–	0.176 ** (2.08)	
EXWM	-0.170 *** (-1.66)	0.119 (1.20)	-0.185 ** (-2.06)
EXPC	-0.455 * (-3.11)	0.172 * (2.61)	

Note: human capital measure-enrollment ratio (H).

Table 10: Granger Causality Tests, TFPM and Import measures

The imports measure	ECT(-1)	D(trade(-1))	D(trade(-2))
IM	-0.753 * (-2.58)	-0.045 (-0.68)	
IMY	-0.245 (-1.57)	-0.132 (-1.36)	-0.158 *** (-1.82)
IMWX	-0.144 *** (-1.94)	-0.085 (-1.43)	
IMPC	-0.753 * (-2.58)	-0.045 (-0.68)	

Note: human capital measure-enrollment ratio (H).

Table 11: Granger Causality Tests, TFPM and Trade measures

The trade measure	ECT(-1)	D(trade(-1))
TV	-0.478 * (-2.35)	0.111 (1.32)
TVY	-0.254 *** (-1.65)	0.035 (0.34)
TVWT	-0.281 ** (-2.04)	-0.069 (-0.78)
TVPC	-0.335 *** (-1.66)	0.079 (0.85)

Note: human capital measure-the share of population with at least 13 schooling years (YS13).

Table 12: Granger Causality Tests, TFPM and Export measures

The exports measure	Independent Variables	
	ECT(-1)	D(trade(-1))
EX	-0.403 * (-2.39)	0.186 * (2.53)
EXY	–	0.157 *** (1.72)
EXWM	-0.070 (-1.05)	-0.110 (-1.27)
EXPC	-0.403 * (-2.39)	0.186 * (2.53)

Note: human capital measure-the share of population with at least 13 schooling years (YS13).

Table 13: Granger Causality Tests, TFPM and Import measures

The imports measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
IM	-0533 ** (-2.19)	-0.019 (-0.26)	
IMY	–	0.010 (0.14)	
IMWX	-0.024 (-1.26)	-0.052 (-0.70)	-0.060 (-0.78)
IMPC	-0.533 ** (-2.19)	-0.019 (-0.26)	

Note: human capital measure-the share of population with at least 13 schooling years (YS13).

Table 14: Granger Causality Tests, GDP and Trade measures

The trade measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
TV	-0.422 ** (-2.29)	0.172 *** (1.92)	-0.039 (-0.42)
TVY	-0.372 ** (-2.29)	0.439 *** (1.92)	-0.040 (-0.42)
TVWT	-0.525 (-0.52)	0.121 (1.47)	0.002 (0.02)
TVPC	-0.351 ** (-2.13)	0.182 *** (1.96)	-0.024 (-0.25)

Note: these causality tests obtined from the multivarite models (that include physical, human capital and labor too).

Table 15: Granger Causality Tests, GDP and Export measures

The exports measure	Independent Variables	
	ECT(-1)	D(trade(-1))
EX	-0.114 *** (-1.84)	0.166 * (2.33)
EXY	-0.009 *** (-1.84)	0.166 * (2.33)
EXWM	-0.050 *** (-1.72)	0.055 (0.79)
EXPC	-0.114 *** (-1.84)	0.166 * (2.33)

Note: see table 14.

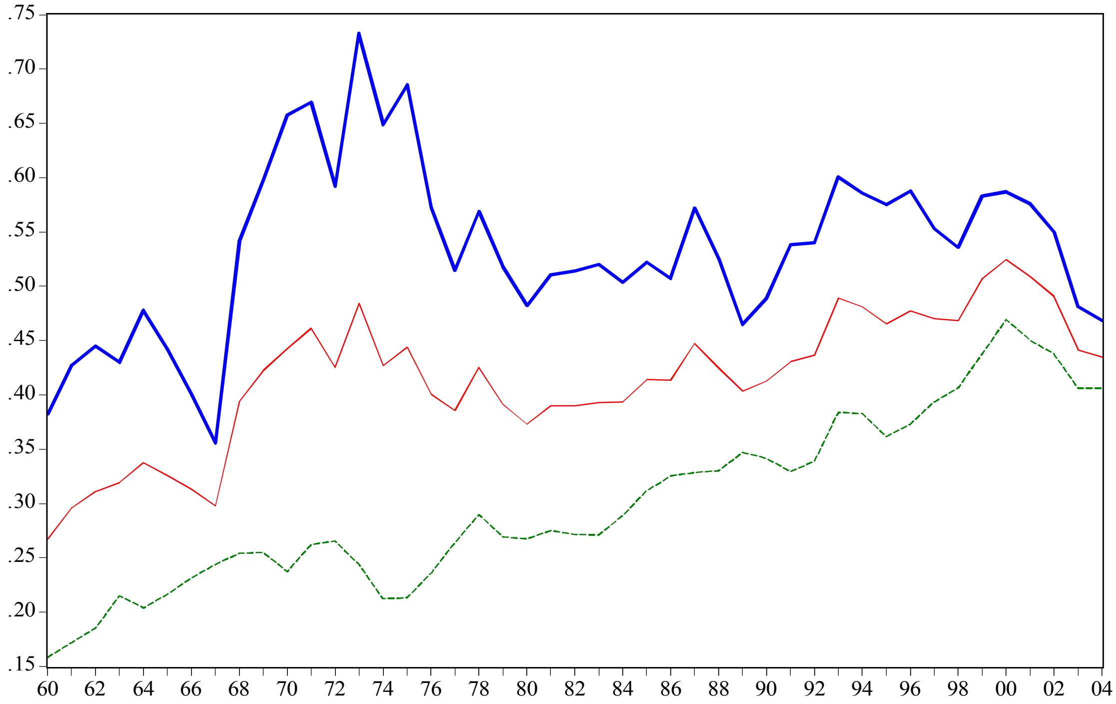
Table 16: Granger Causality Tests, GDP and Import measures

The imports measure	Independent Variables		
	ECT(-1)	D(trade(-1))	D(trade(-2))
IM	-0.491** (-2.17)	0.138 ** (2.14)	-0.043 (-0.56)
IMY	-0.524 ** (-2.17)	0.138 ** (2.14)	-0.043 (-0.56)
IMWX	-0.076 (-1.55)	0.125 *** (1.65)	-0.001 (-0.02)
IMPC	-0.491** (-2.17)	0.138 ** (2.14)	-0.043 (-0.56)

Note: see table 14.

Appendix 5: Graphs

Figure 1: Israeli Trade share in world trade, in percents, 1960-2004



Note: Thin Line-the share of Israeli trade in world trade; thick line- the share of Israeli imports in world exports; dashed line- the share of Israeli exports in world imports.

Figure 2: Israeli Trade share in world trade, in percents, 1960-2004