The Effects Of Education On Labor Productivity: Differences Between Tradable And Non-Tradable Industries

Elise S. Brezis (Aharon Meir Center for Banking and Economic Policy, Bar-Ilan University, Israel) and Gilad Brand (Bar-Ilan University and The Taub Center for Social Policy Studies)

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The Effects of Education on Labor Productivity: Differences between tradable and non-tradable industries

Elise S. Brezis* and Gilad Brand**

Abstract

This research focuses on the differences in labor productivity between tradable and non-tradable industries, and the contribution of human capital to the differences between these two sectors. We find that while productivity rose substantially in the tradable sector, in the non-tradable sector, output per worker has remained the same; although, the rise in human capital in both sectors does not differ significantly.

This paper emphasizes that heterogeneous ability of individuals as well as a double duality both in the labor market and the higher-education might explain these facts. The double duality in the economy permits a separation of individuals by their ability, which can explain the differences in labor productivity between sectors.

Keywords: productivity, traded goods, services, duality, higher education, human capital, wage premium.

JEL classification: I23, I26, J24, J31, O14.

* *Head, Aharon Meir Center (AMCB), Bar-Ilan University* elise.brezis@biu.ac.il

** *Bar-Ilan University, and Taub Center* giladmbrand@gmail.com

I. Introduction

Various measurements of innovation density find Israel to be ranked on par with the wealthier and more advanced economies, excelling in R&D and high tech.[1] It has been coined the “start-up nation”. Yet, Israel's labor productivity is relatively low compared to other developed countries, (Figure 1). Moreover, Israel is not short of investments in human capital: Over the past twenty years, there was an increase in the attainment of higher education in Israel, and the share of adults with tertiary education in Israel exceeds most OECD countries (Figure 2).

This research focuses on the differences in labor productivity between the tradable and the non-tradable industries, and the contribution of human capital to the difference between these two sectors. A priori, we could assume that the non-tradable sector, which mostly includes services, would have a low content of human capital, and that this fact would be the main difference between these two sectors, i.e., the tradable sector has high content of human capital, and the non-tradable has a low content of human capital. Indeed, Figure 3 shows the relative content of tradable vs. non-tradable, and there seems to be a correlation between the tradability of an industry and the average years of schooling of its workers. So this difference in human capital could explain the gap in labor productivity.

However, over the last two decades, there was an increase in the content of human capital in the non-tradable sector. In Figure 4, the rise in human capital in the non-tradable sector does not differ significantly from the rise in human capital in the tradable sector. Despite this increase in human capital in the non-tradable sector, we find that productivity rose substantially on the tradable side, but on the non-tradable side, output per worker has remained the same. These facts can indicate that education might be associated with a rise in productivity only in the non-tradable sector.

The purpose of this paper is to develop a framework which can assemble the various pieces of the puzzle together. This paper emphasizes that a double duality in the economy might explain the facts presented above. Indeed the Israeli economy displays a duality in both the output sector and the education sector: The labor market is divided into two very different economies: The tradable sector which comprises mainly high tech but also traditional manufacturing industries, and the non-tradable sector which comprises mainly

[1] Bloomberg 2016 Innovation Index finds Israel to be the world's 11th most Innovative Economy. In the categories "R&D Intensity" and "Researchers Concentration" Israel is ranked first and ranks seventh in the category "High Tech Density". INSEAD and WIPO's Global Innovation Index has rewarded Israel with a similar ranking as well.

trade and service industries. The labor productivity in these two aggregated sectors is very different (Table 1).

But this is not the only duality in the economy: The Israeli economy displays a duality in higher education. There is not one channel of higher education, but two: graduating from a prestigious university, or graduating from a local college.[2]

The Israeli higher education sector displays two separate channels of education, due to separate entry exams in the various types of universities and faculties. While one needs a score in the top 15^{th} percentile on a psychometric test[3] (equivalent to an SAT exam) to enter computer science and a score in the top 35^{th} percentile in Economics in Tel-Aviv University or Bar-Ilan University., one needs only to pass the bottom 30^{th} percentile in the faculty of humanities, and no exam at all to enter all colleges (which usually do not offer science courses or computer science).

This paper will show that the duality in the sector of higher education permits to differentiate individuals with high and low ability, and this is part of the explanation of the strong division between the tradable and non-tradable sectors. The related explanation is the complementarity between capital and human capital in the tradable sector, whereas the non-tradable sector is a function only of labor and human capital. All these elements together permit us to assemble the various pieces of the puzzle displayed by the Israeli economy.

Indeed our main proposition stresses that the double duality in the economy permits a separation of individuals by their ability. In other words, individuals with high ability will work in the tradable sector, while individuals with low ability will work in the non-tradable sector. This separation of abilities could explain the difference in labor productivity between sectors.[4]

The paper is divided into 6 sections. In the next section, we present the literature. In section III, the empirical regularities are put in evidence. The model is presented in section IV, and in section V the empirical analysis is discussed. Section VI is the conclusion.

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[2] The last decade, there was a huge increase in the intake of tertiary education, but this was mainly due to rise in enrolment rates in local colleges (see Figure 5).

[3] Acceptance typically is based on a combination of matriculation grades and psychometric tests.

[4] This version of the paper is very preliminary, since there are no dynamics, which will be introduced in the next version.

II. Related Literature

2.1 Productivity

Standard Economic theory predicts that labor productivity, defined as value added per hour worked, will converge over time conditional on physical and human capital intensity and the specific characteristics of each country. However, labor productivity levels and productivity growth in Israel is relatively low compared to other developed countries, reflecting a process of divergence (figure 6).

The empirical literature finds that the gap between productivity in Israel and other OECD countries can be attributed to an array of unique characteristics of the Israeli economy.[5] For instance, the Bank of Israel- BOI (2013) found that the productivity gap can be attributed to extensive bureaucracy, long-work hours and a relatively young labor force. The study also mentions low competition in the local business environment as a possible explanation.[6] Geva (2015) finds that about 24% of the productivity gap can be explained by low capital-output ratio with the remaining 76% being a result of low TFP rates. His study finds that a sizable defence sector and low achievement in core curriculum subjects in Israel's education system can explain part of the gap in TFP rates. In an examination of the productivity gap on an industry level, the BOI (2014) finds a negative correlation between an industry export rate and its productivity gap. In a comparison to 12 OECD countries[7] Regev and Brand (2015) show that the exposure of an industry to competitive imports is correlated with the change in productivity gaps over time. This research also shows that the productivity gap is primarily concentrated in the non-tradable industries.

Whereas aggregate productivity is expected to converge based on a country's unique characteristics, Rodrick (2011) finds that GDP per worker in the manufacturing industries tends to converge unconditionally. This could explain the different trends of productivity growth in the tradable and non-tradable industries. Spence and Hlatshway (2012) find that the incremental productivity growth in the US in the period 1990-2008 stems from the tradable sector, while virtually all employment is generated in the non-tradable industries. De Michelis et al. (2013) and Junankar (2013) find a negative relationship between labor force growth and productivity growth. Therefore the different trends in productivity growth may be tied to their opposite employment trends.

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[5] GDP per hour worked in Israel is approximately 76% of the OECD average and only about 63% of the G7 average (Figure 1). Moreover productivity growth has been falling behind, resulting in divergence from other OECD countries (Figure 6).

[6] Boulhol et al. (2008) find that proximity to areas of dense economic activity can account for differences in GDP per capita across countries, hence Israel's geographic location may account for part of the productivity gap.

[7] Austria, Canada, Czech Republic, Denmark, Finland, Greece, Hungary, Netherlands, Norway, Slovakia, Spain, and Sweden.

Tradable industries are more prone to knowledge diffusion via global connections, FDI and mobility of skilled labor. The nature of the activity of these industries is more technologically dynamic and more likely to be revolutionized by innovation. As a consequence, productivity tends to rise faster in the tradable industries, a phenomenon well-known for many years. Furthermore, since higher productivity results in a flow of skilled labor and capital investments, the productivity of the tradable relative to the non-tradables tends to widen in accordance with aggregate economic growth. Rodrick (2016) finds that a rapidly growing non-tradable sector, and in particular a swift decline in employment in manufacturing industries, can hinder the productivity convergence in middle income economies.

Micro data on a firm level further strengthens this assertion, and evidence showing that exporting firms tend to outperform the non-exporters has been well documented in the literature. Greenaway and Kneller, (2008) describe the empirical findings of learning by exporting effect, emphasizing that exposure to foreign competitors, new clients and fierce competition in international markets will result in increasing efficiency and greater investments in new technologies.

2.2 Heterogeneity of workers

Balassa (1964) and Samuelson (1964) assumed that a rise in productivity on the tradable side would result in a transfer of workers from the non-tradable to the tradable side of the economy. Thereafter the non-tradable firms would be subjected to wage pressure resulting in an increase in the overall wage level and a rise in the price of non-tradable commodities. Yet Lavy and Friedman (2007) found the Balassa and Samuelson effect to be absent in the Israeli economy and attribute this to a segmented labor market. They find that workers' characteristics in the tradable industries differ greatly from those on the non-tradable side resulting in low mobility between the sectors. Brand and Regev (2015) find that the trade liberalization reform resulted in a quick and substantial movement of low skilled workers from traditional manufacturing industries to the lower wage tier of the non-tradable industries. Among the high skilled, a movement in the opposite direction was observed.

2.3 Duality in higher education and the effects of education on productivity

The duality in higher education has been mainly emphasized in relation to social mobility and inequality, and not so much in relation to productivity. Indeed, Brezis and Hellier (2016) show that a dual higher-education system characterised by the concomitance of both standard and elite universities generates permanent social stratification, high social immobility and self-reproduction of the elite. Moreover, Kerckhoff (1995) suggests that the

effect of family backgrounds could be magnified when the education system is highly stratified and selective. This argument has been confirmed by several empirical works (Hanushek and Woessmann, 2006; Pfeffer, 2008; Dronkers et al., 2011). Indeed, in the recent economic literature on education and human capital, there has been a growing interest into the analysis of stratification of educational systems (see Brezis and Temin, 1999, 2008).

The impact of education on economic growth has been a major topic in economic research. From the early studies by Becker (1962), Mincer (1974) and Schultz (1971) to the literature which followed Romer's (1990) endogenous growth theory, human capital accumulation has been regarded as a key determinant of long-term economic growth. Yet there is an emergence of an empirical literature which cast doubt on the positive effect of an increase in human capital on economic growth. The results of Pritchett (2001), Krueger and Lindhal (2002) and Benhabib and Spiegel (1994) show that when human capital is one homogenous variable, usually depicted by the average years of education, then human capital does not affect economic growth. So, human capital in the form of a homogenous education does not seem to affect economic growth in the data.

With the use of scores on internationally comparable examinations, Hanushek and Woessmann (2008, 2012) and Barro (2013) have stressed the importance of school quality and cognitive skills rather than school quantity. Similarly, Altinok and Aydemir (2016) show that the effect of school quality on growth differs across regions and by the economic level of countries. Brezis and Crouzet (2006) show that differences of quality and recruitment among universities lead to adopt different types of new technologies, which affect the level of economic growth.

III. Empirical Regularities

The Israeli labor market as well as the higher-education system presents some specificities we emphasize in this section; some of the facts are similar to the regularities in other countries, while others are specific to the Israeli economy. We start by focusing on heterogeneity of workers, and differences in productivity, and then differences in returns of factors of production. The division between the tradable and non-tradable industries and the source of the data are explained in section 5.1.

3.1 Heterogeneity of workers between sectors

The distribution of the workers psychometric scores are displayed in Figure **7** and summary statistics are shown in Table 2. As is shown, while workers' ability in the non-tradable sector is normally distributed, ability among workers in the tradable sector is

strongly skewed to the right, suggesting that substantial differences exist in workers' ability in each industry group.[8] Accordingly, we also find significant differences in the quality of obtained education. Whereas 68% of workers in the tradable industries (in the age group 27-32) have obtained their education from a university, this number drops to only 51% among the non-tradable industries.

Moreover, BOI (2016) finds similar results. Combining the results of the recently published OECD Survey of Adult Skills (PIAAC), the BOI (2016) finds, on an industry level analysis, that whereas the share of workers with higher education relative to the OECD is not positively correlated with the productivity gaps; PIAAC test results are positively correlated. This finding suggests that the quality of education may vary significantly across industries.

3.2 Different Productivity in the tradable and non-tradable industries

TFP growth rates in the trade and services vs. manufacturing industries are different (Figure 8), representing the tradable and non-tradable side of the economy, accordingly. This comparison, which spans from 1975 up until 2015, shows that until the early 1990s, there was an almost perfect correlation between productivity growth in the two industry groups, whereas after that period, growth in manufacturing industries began to accelerate, along with a minor decrease in productivity in the non-tradable industries. A more precise division between the two industry groups reveals similar results (Figure 9). Only minor differences in productivity levels in the two industry groups were found in 1995, yet the rapid growth on the tradable side and lack of growth in the non-tradable industries has resulted in widening of the gaps. This can also be shown by calculating the cumulative distribution of productivity in 1995 and 2010 (Figure 10). Whereas on the tradable side the latter has first order stochastic dominance over the former, this is clearly not the case in the non-tradable industries.

3.3 Wages of skilled workers in tradable and non-tradable industries.

The tradable industries tend to pay higher wages than non-tradable industries. Figure 11 shows a strong correlation between the extent in which an industry is open to international trade and the annual average wage level. Higher wages are found also when controlling for workers' observable characteristics. As shown in Figure 12 a wage gap between the two sectors exists and the gap has further increased over the examined time period.

Accordingly, return on education was found to be higher in the tradable industries. The results illustrated in Figure 13 show that the college wage premium has remained relatively

[8] This conclusion is supported by a simple Kolmogorov–Smirnov test ($p<0.01$).

stable in the non-tradable industries while a steady increase was found in the premium on the tradable side. Moreover, the premium was found to be on the same level in both industry groups in 1995, yet by 2010 the premium in the tradable side was notably higher.

To conclude, while education rates have increased across all segments of the labor market, productivity has taken a much less uniform course. On the tradable side, productivity has risen sharply, but on the non-tradable side productivity has reached a near standstill. The model presented in the next section will try to give an explanation to these facts.

IV. The model

4.1. Introduction

Our framework assumes that there is heterogeneity (i) among sectors, (ii) in the higher education market (iii) among individuals. In other words, not only individuals differ in their abilities; but sectors have different production functions and therefore different needs for human capital, and also the higher education system is not homogeneous.

In this model, some of the workers acquire higher education. So the workers are either workers without skills, L or workers with skills due to the fact that they have invested in higher education, H. However education is not homogenous. Individuals can either learn in a top university, or equivalently in sciences (H_E for exact science, or elite universities) or learn in a standard university (or in a faculty of humanities (H_{NE} for non elite, or humanities). Indeed, the duality in higher education can take two quite equivalent forms. Either one wants to focus on the duality in the type of faculties (science versus humanities), or one prefers to focus on the duality between elite universities vs. standard universities. For both dualities, the reasoning is the same.[9] The type of education the individual acquires is common knowledge, since it is acknowledged on his diploma.

4.2. Ability

We assume that individuals are born with different abilities, either high denoted a_h, or low denoted a_l. We assume a proportion gamma of individuals with high ability. Moreover, for sake of simplicity we assume that $a_h = \delta a_l$ where $\delta > 1$.

[9] In this version of the paper, since we have gathered data on the duality between elite and standard universities, which is called colleges in Israel, we will focus on the second type of duality, i.e., elite vs standard universities.

This difference in ability affects the economy through two channels. First, smarter people learn more rapidly, and therefore for getting the same grade, they have to invest much less effort than the person with low ability. We can all cite examples that in the same class, some students can just, for once, look at the math book, and will solve almost all exercises. Some others will have to redo 10 times the same exercise to know to solve it.

The second channel is through the market labor. Ability affects the productivity of individuals, and individuals with high ability will have a higher productivity for doing the same job.

We start the presentation of the model with the utility function, then we move to the production section, and then to the educational market.

4.3. The utility

There are two sorts of goods in the economy, traded, T and non-traded, NT. Consumers want them both, and we assume an elasticity of substitution of 1 between these goods, so the utility function will take a Cobb-Douglas form such as:

$$U(T, NT) = T^{\pi} NT^{1-\pi}. \qquad \text{where } 0 < \pi < 1 \tag{1}$$

In the next section, we present the production functions. We start with the tradable sector.

4.4 The tradable sector.

The tradable sector uses 3 factors of production, L, H and K. We assume a CES function between H and L, that is human capital and labor are substitute factors of production, and we assume that labor, L and capital K have a constant rate of substitution of 1.

H is not homogenous, we have in fact two different types of human capital, H_E and H_{NE}. The two types of human capital are perfect substitute. The productivity of each H is a function of the average ability of the skilled workers having acquired this type of education (a_1, a_2). Moreover, human capital acquired through education in elite university/science adds a productivity of λ. So the tradable sector has the following production function

$$Y_T = K^{1-\beta}[(a_1 H_{NE} + \lambda a_2 H_E)^{\rho} + (a_u L)^{\rho}]^{\frac{\beta}{\rho}}. \tag{2}$$

Where β, ρ are both between 0 and 1. The respective costs of the factor of productions of L, H_{NE}, H_E and K are: W_u, W_S^l, W_S^h,and *r*.

4.5 The non-tradable sector.

The non-tradable sector uses 2 factors of production, H and L.

The two types of H are perfect substitute. So the NT sector has the following production:

$$Y_{NT} = [(a_1 H_{NE} + \lambda a_2 H_E)^{\alpha} + (a_u L)^{\alpha}]^{\frac{1}{\alpha}}. \qquad (3)$$

4.6. The Higher Education sector.

There are exams for entry to the different faculties/ universities. There are faculty of sciences / elite universities, in which when graduating, the student acquire a human capital of type H_E; and there are faculties of humanities/colleges, in which the student acquires human capital of type H_{NE}.

The grades on the entry exam (SAT) to gain access to the faculty of sciences/elite universities, are much higher than the grades to enter humanities/colleges.[10]

In consequence, we get the following partition. Students with a high grades on his SAT will get access to science/elite universities and acquire human capital of type H_E. Students with lower grades (but with a baccalaureat) will register to humanities/colleges, and will acquire human capital of type H_{NE}. Finally, individuals without a baccalaureat will stay unskilled, and display a factor of production, L.

The individuals with a baccalaureat can register to classes which are helping them to these SAT exams. The costs for taking these exams is the price per hour of these classes, P, multiplied by the number of hours necessary for preparing for these exams. Individuals whose ability is low need plenty of time for the acquisition of the knowledge (i.e., he needs to invest high effort, e_l), whereas individuals whose ability is high need low investment (e_h). For matters of simplicity, we assume that efforts are inverse to the ability level, so that $e_h = 1/a_h$ and $e_l = 1/a_l$.

So the costs for each individual for entering sciences/elite universities are:

$$C_h = P.e_h = \frac{P}{a_h} \qquad \text{for individuals with high ability} \qquad (4)$$

[10] In different countries, it has a different name. In the US, it is SAT, in Israel, the "psychometric exams", in France the "prep exams".

$$C_l = P.e_l = \frac{P}{a_l} \qquad \text{for individuals with high ability} \tag{5}$$

And we get that $C_l > C_h$

We assume that the costs for entering humanities/colleges are 0 for high-ability individuals while the costs for low-ability is low but not zero, and we assume it is: $c = P/\gamma a_l$ with $\gamma \geq 2$ and $\delta > \gamma/(\gamma - 1)$.

4.7. The Equilibrium.

Let us find out, whether there is separation between types of ability. In order to do so, we will present three lemmas.

Let us first define condition I on wages, and then present lemma 1.

Condition Ia: $\frac{P}{a_l}(\frac{\gamma - 1}{\gamma}) > W_S^h - W_S^l > \frac{P}{\delta a_l}$ **Condition Ib**: $W_S^l - c > W_u$

Lemma 1.

Under condition I, all individuals with low ability will acquire higher education of type H_{NE}, while individuals with high ability, will get access to elite universities and acquire human capital of type H_E.

Individuals who do not have a *baccalaureat*, and did not finish high school, will not have access to a university or college.

Proof

Let us assume that indeed all individuals of high ability acquire H_E, and individuals with low ability go to learn in humanities/colleges. We show that this is an equilibrium, i.e., no individual wants to diverge from this equilibrium.

a). For a high ability person, from the right hand side of Condition Ia, it is easy to show that we get the following inequality :

$W_S^h - C_h > W_S^l$

The inequality means that high ability individuals get a higher income from investing in education in science/elite university than from getting a degree in humanities/college

(remember that costs for high ability to learn in humanities is 0). In consequence we have shown that indeed high ability individuals prefer to learn at elite universities/ science.

b). For a low ability person, under condition Ib and the right hand side of condition Ia, we get the following inequalities (remember that for high ability, cost of learning in college/humanities is c). So:

$$W_S^l - c > W_S^h - C_l > W_u$$

In consequence low ability individuals enter a college/ humanities.
So we get that there is a duality in higher education: individuals with high ability acquire H_E, and individuals with low quality acquire H_{NE}.
We now check whether there is also duality in the labor market.

Let us define Condition II:

Condition II: $$\frac{\lambda W_S^l}{a_1} > \frac{W_S^h}{a_2} > \frac{W_S^l}{a_1}$$

We then get the following Lemma.

Lemma 2
Individuals with human capital of type H_E will all work in the tradable sector, and the individuals with human capital of type H_{NE} will work in the non-tradable sector.

Proof
(i) Let us analyze the tradable sector. From the production function displayed in equation (2), human capital of types H_E and H_{NE} are perfect substitute. In consequence the producer will employ the type which is the cheapest for him for producing the same amount of output.
One worker of type H_E is producing λa_2 at costs W_S^h, while the worker of type H_{NE} is producing a_1 at cost W_S^l.
It is less expensive to hire workers having graduated from science/elite universities if:

$\frac{W_S^l}{a_1} > \frac{W_S^h}{\lambda a_2}$ which is equivalent to the left hand side of condition II.

(ii) About the non-tradable sector, from equation (3), one worker of type H_E is producing a_2 at costs W_S^h, while the worker of type H_{NE} is producing a_1 at cost W_S^l.

It is less expensive to hire workers having graduated from colleges/humanities if:

$\frac{W_S^h}{a_2} > \frac{W_S^l}{a_1}$ which is equivalent to the right hand side of condition II.

QED.

We now turn to the Proposition.

Proposition

Under Conditions I and II, individuals with high ability will work in the tradable sector, and individuals with low ability will work in the non-tradable sector.

Proof

From Lemma 2, workers in the tradable sectors are with education of type H_E. From Lemma 1, those with education type H_E are of high ability. In consequence, individuals with high ability work in the tradable sector. Following the same reasoning, individuals with low ability will work in the non-tradable sector.

Since the only skilled workers in the tradable sector are of high ability, we then get that $a_2 = a_h$, and the production function takes the following form:

$$Y_T = K^{1-\beta}[(\lambda a_h H_E)^\rho + (a_u L)^\rho]^{\frac{\beta}{\rho}}. \quad (6)$$

Following the same reasoning, the equation of the non-tradable sector is:

$$Y_{NT} = [(a_1 H_{NE})^\alpha + (a_u L)^\alpha]^{\frac{1}{\alpha}}. \quad (7)$$

4.8. Wages and Wage premium.

Let us now find out the wages, W_u, W_S^l, W_S^h.

The marginal products of H_E and L are equal to their wages, so:

$$W_u = \frac{\partial Y_T}{\partial L} = \beta K^{1-\beta} {a_u}^{\rho} [(\lambda a_h \frac{H_E}{L})^{\rho} + (a_u)^{\rho}]^{\frac{\beta-\rho}{\rho}} L^{\frac{\beta-\rho}{\rho}} . \quad (8)$$

and:

$$W_S^h = \frac{\partial Y_T}{\partial H_E} = \beta K^{1-\beta} \lambda {a_h}^{\rho} [(\lambda a_h)^{\rho} + (a_u \frac{L}{H_E})^{\rho}]^{\frac{\beta-\rho}{\rho}} H_E^{\frac{\beta-\rho}{\rho}} . \quad (9)$$

So that the wage premium of education of type H_E is:

$$\omega_1 = \frac{W_S^h}{W_u} = (\frac{\lambda a_h}{a_u})^{\rho} (\frac{H_E}{L})^{\frac{\rho(\beta-\rho)}{1-\rho}} . \quad (10)$$

From the non-tradable function of production, the marginal products of H_{NE} and L are equal to their wages, so:

$$W_u = \frac{\partial Y_{NT}}{\partial L} = {a_u}^{\alpha} [(a_l \frac{H_{NE}}{L})^{\alpha} + (a_u)^{\alpha}]^{\frac{1-\alpha}{\alpha}} . \quad (11)$$

$$W_S^l = \frac{\partial Y_{NT}}{\partial H_{NE}} = {a_h}^{\alpha} [(a_l)^{\alpha} + (a_u \frac{L}{H_{NE}})^{\alpha}]^{\frac{1-\alpha}{\alpha}} . \quad (12)$$

And the wage premium of education of type H_{NE} is:

$$\omega_2 = \frac{W_S^l}{W_u} = (\frac{a_l}{a_u})^{\alpha} (\frac{L}{H_{NE}})^{1-\alpha} \quad (13)$$

From (10) and (13), we get that the wage premium of education of type H_E vs. type H_{NE} is:

$$\omega_3 = \frac{W_S^h}{W_S^l} = (\frac{a_l}{a_u})^{-\alpha} (\frac{H_{NE}}{L})^{1-\alpha} (\frac{\lambda a_h}{a_u})^{\rho} (\frac{H_E}{L})^{\frac{\rho(\beta-\rho)}{1-\rho}} \quad (14)$$

Lemma 3

With production functions as presented in equations (6) and (7), Conditions I and II holds.

Proof

(in the next version)

Lemma 3 permits us to simplify the equations presented in a general manner (equations 2 and 3) to equations (6) and (7). Since conditions I and II holds, this means that the model is stable and that indeed the separation equilibrium is stable and no individual has a reason to deviate from his position. Therefore, low ability workers indeed graduate from colleges and will go to work in the non-tradable sector. For high ability workers, they will graduate from elite universities, and work in the tradable sector. This separation permits us to calculate the wage premium, when workers with different abilities work in different tasks. Since their ability is different, and the elite universities offer a better education, the high ability workers have a double reason for higher productivity (a_h and λ). This explains the gap in productivity.

4.9. Conclusion of the model

The model has permitted to explain the following facts. (i) From Proposition we get that people with high ability (i.e., high grade on SAT) are the ones working in the tradable sector and the opposite. This is what has been emphasized in section 3.1.

(ii) Productivity of workers in the tradable sector is higher than in the NT sector (since one is a function of λa_h and the other one a_l.); This is what has been emphasized section 3.2.

(iii), from equation 14 we see that the relative wage is lower than 1, so wages of skilled workers in the tradable sector is higher than in the non-tradable sector. This is what has been emphasized in section 3.3.

In conclusion, the double duality in the labor and higher education sectors is essential for explaining the empirical regularities presented in section III.

V. Empirical Analysis

In this part of the paper, we analyse the relationship between output productivity, openness and education. We do so by running a simple regression in which the annual average growth rate of productivity determined by the initial log level of productivity and the initial log school years. We also control for the degree in which the industry is exposed to international trade and an interaction term between the initial log level of education and the openness ratio.

More specifically the regressions we will perform is:

$$\Delta gdp\ per\ hour_i = \alpha_1 + \alpha_2 \ln(gdp\ per\ hour_i) + \alpha_3 \ln(gdp\ per\ hour_i)^2 + \alpha_4 openness\ ratio_i + \alpha_5 \ln(school_i) + \alpha_6 openness\ ratio_i \cdot \ln(school_i) + \varepsilon_i$$

Where i is an industry index; $\Delta gdp\ per\ hour$ is the annual average growth rate of productivity; $gdp\ per\ hour$ is the level of productivity in 1995; $school$ is the average years of schooling in 1995; $openness\ ratio$ is a measure of the openness of each industry ranging from 0-1.

5.1 Data

5.1.1 The sample

Using historical time series data and labor surveys conducted by the Central Bureau of Statistics (CBS), the study builds upon a data set ranging from 1995 up to 2010, allowing for employment, output and educational trends to be examined.

We focus only on the non-mining/non-real-estate business sector and further exclude the agricultural and construction industries which rely heavily on foreign labor (i.e non-Israeli workers from abroad employed on a somewhat temporary basis). In consequence, we have 42 sectors which account for about two-thirds of the labor market.[11] The data is available up until 2011.

5.1.2 The trade openness index

In order to measure the openness of each industry we employ the Input-Output tables, available for the year 2006, and devise a trade openness index. The index measures the share of exports and competitive imports within the total supply of the industry. This measurement yields an index ranging from 0-1, indicating the extent in which an industry is exposed to foreign competition.

Subsequently we divide the industries into two distinct tradability groups: tradable and non-tradable sectors. Using the trade openness index we set the cutoff point at 0.4, meaning industries with higher openness ratio are included in the tradable sector and the remaining in the non-tradable industries. Using this division leaves us with 19 tradable industries which consist mostly of high-tech and the bulk of the manufacturing industries. The 23 remaining non-tradable industries consist of most of the trade and services industries.

[11] This database consists of surveys of Trade, Services, Transport, Communications and manufacturing conducted by the Israeli Central Bureau of Statistics. Micro data on wages and employment characteristics were collected using income and labor surveys.

Finances and banking activities were classified as non-tradable since these industries in Israel are engaged mostly in the local market (see Table 1). We find that this division represents the tradable and non-tradable side of the economy well and the results are quite robust and not sensitive to the cutoff point. In addition, we have gathered data on the workers in the tradable and non-sectors by the type of university they attended, their psychometric exam score, and industry in which they are employed. The data is available to us for the year 2011 for workers in the age group 27-32 (n=68,664). The data was restricted to workers who completed at least an undergraduate degree and were employed at the time of the survey on a full time basis.

5.2 . The Results.

Results are presented in Table 3. Our main interest is the interaction term found to be positive and significant ($p<1\%$) indicating that *school* x *openness ratio* is influential for productivity growth. Omitting the interaction term from the regression reduces the explanatory power of the regression, and the coefficient of $\ln(school)$ remains insignificant. These results indicate that trade is a key determinant of the link between education and international growth.

Putting all our results together, we can conclude that as an economy becomes more open to trade, education accumulation can gain a stronger effect on productivity growth in the tradable industries.

5.3 Further analysis

We perform some more exercises which are more in phase with the standard models in which it is assumed that individuals are homogeneous in ability. Indeed, if all individuals were assumed homogeneous, then we would find a difference in the matching between occupation and education. Indeed, when we compare the growth rate of workers with higher education to the rise in occupations which require such education, we find that on the tradable side these two variables tend to move together, while in non-tradable industries, the latter is growing at a pace three times faster than the former (Figure 14). As a consequence, when we assume homogeneity of workers, this is a strong indication that supply of educated workers has risen faster than demand. However, according to our model, which assumes heterogeneity of workers, this exercise can be interpreted as if the type of occupation would differentiate between skilled with high ability, and skilled with low ability.

The same dichotomy of interpretation exists on the wage premium. Our paper shows that indeed wage premium has increased in a different manner in both sectors, due to the fact

that individuals have different abilities (Figure 13). If we would apply the Katz and Murphy (1992) framework, which assumes homogeneity of workers, when supply grows faster than the demand for skills, then the college wage premium will fall. When supply growth falls short of this rate, the skill premium will increase. When examining the different segments of the labor market, we find that the wage premium has increased in the tradable sector and reached a near standstill on the non-tradable one. This finding refutes the assumption that supply of skill has exceeded the demand.

Our interpretation is different. Since the type of higher education can signal the ability of the worker, the workers in high-tech in particular and the tradable sector in general have a double value-added relative to the workers in the non-tradable sector. On the one hand, they possess better ability (a_h vs. a_l) and on the other hand, they obtained an education which gives them a lead in productivity (λ). Therefore, the double duality, and the fact that indeed we have found that workers are of different abilities in the two sectors, explain all the facts related to the wage premium, without entering the debate related to supply and demand.

VI. Conclusion

This paper analyzes three main differences which exist between the tradable and non-tradable sectors. The first one is the differences in productivity, and the second one is related to the differences in the wage premium to education. The third difference is the ability of individuals working in these two sectors. Indeed, the data show that human capital varies between the tradable and non-tradable industries. The average ability is higher in the tradable sector. Therefore human capital and its causal effect on productivity would be better analysed as a heterogeneous factor of production, as done in our model.

It is interesting to note that the role of higher education and human capital has evolved over the decades. In the past, human capital was interpreted as the factor of production which represented the skills of workers. It was homogenous. Today, human capital takes different forms and human capital is not anymore a homogenous factor of production.

In consequence, in this paper, we differentiate between types of education and abilities of individuals. On the one hand, individuals can be with low or high ability. On the other hand, individuals can graduate either from prestigious universities or from standard colleges. Our model has shown that there is a relationship between abilities and types of education: Individuals with low ability are more prone to graduate from standard universities, while high ability students graduate from elite schools and from prestigious

faculties. It is this disparity which explains all the various differences between the service sector and the manufacturing ones.

On the empirical side, we have analyzed the Israeli economy from 1995 to 2011. More specifically, we build an openness ratio index in order to indicate the sensitivity of the economic sectors to foreign competition. Subsequently, we divided the labor market into tradable and non-tradable components enabling both sectors to be examined. We have found that productivity is different between both sectors, that the wage premium is higher in the tradable sector, and that the ability of workers is lower in the non-tradable sector.

This paper has specifically analyzed the Israeli market, but this duality in both production sectors and higher education is probably taking place in other countries. Our next goal will therefore be to apply our analyses to other countries.

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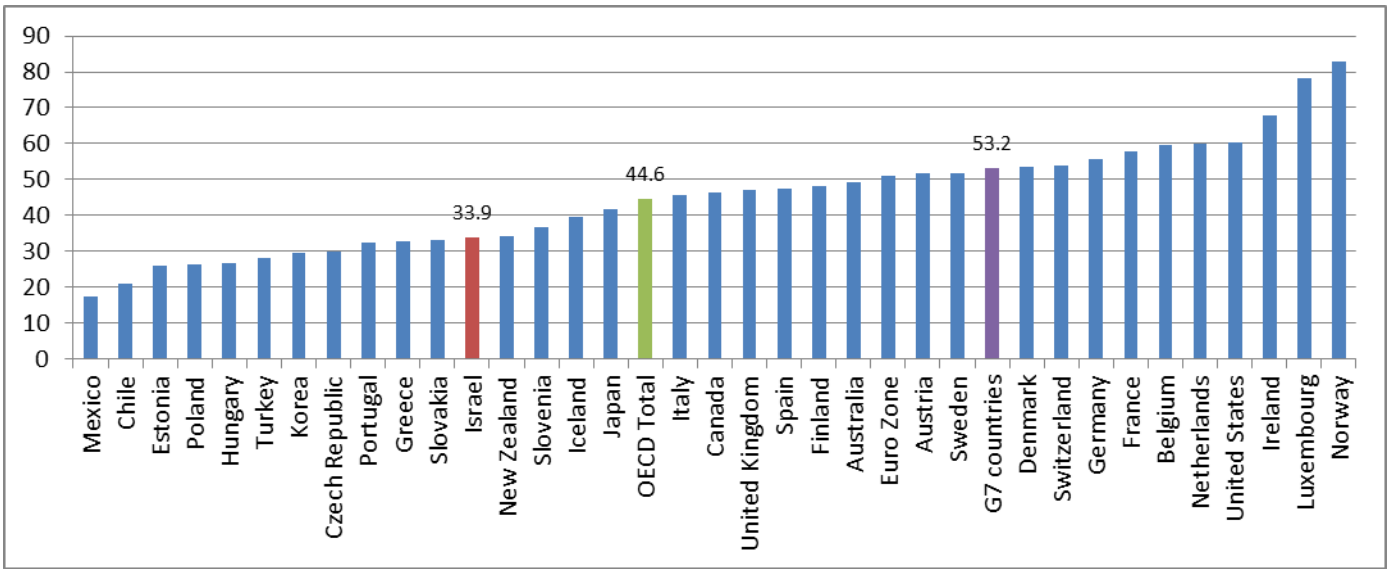
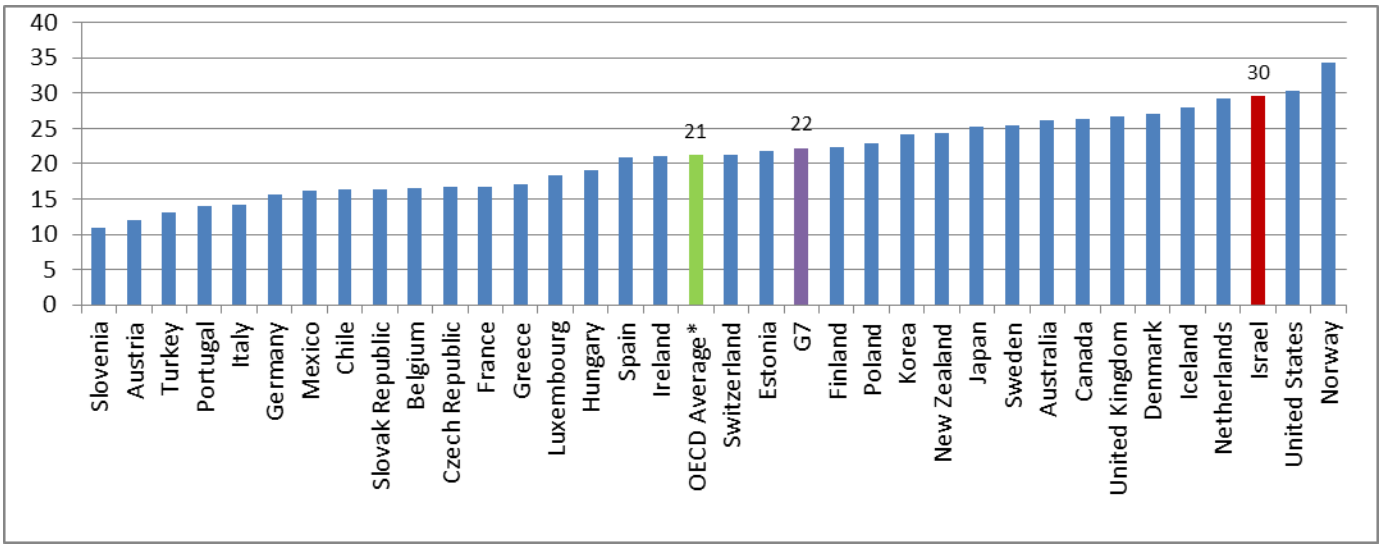
Figures and Tables

Figure 1: GDP per hour worked in 2011, current USD in PPPs.



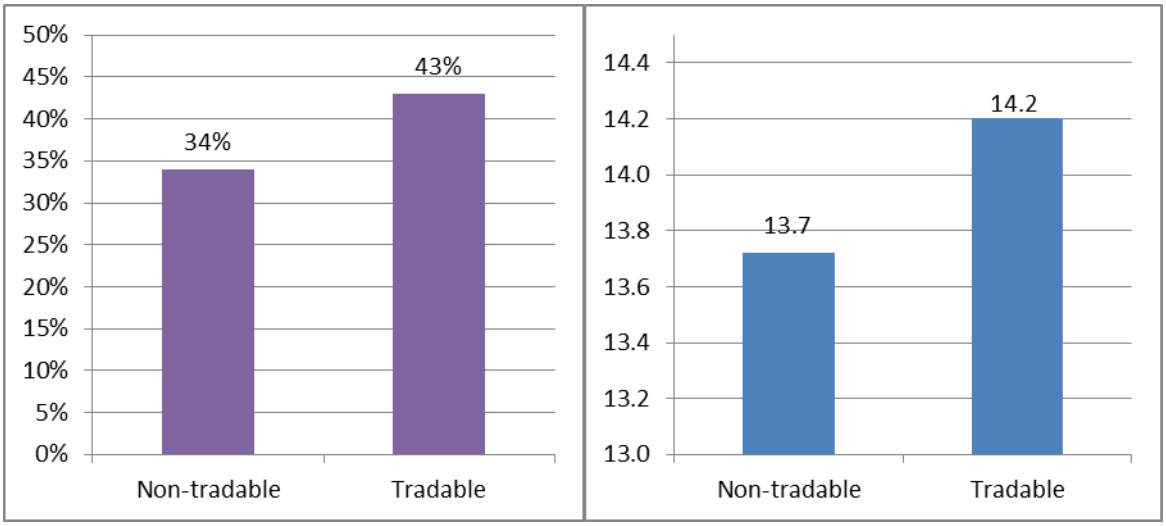
Source: OECD stat

Figure 2: Share of adults (25-64 year-olds) with tertiary education in 2011*



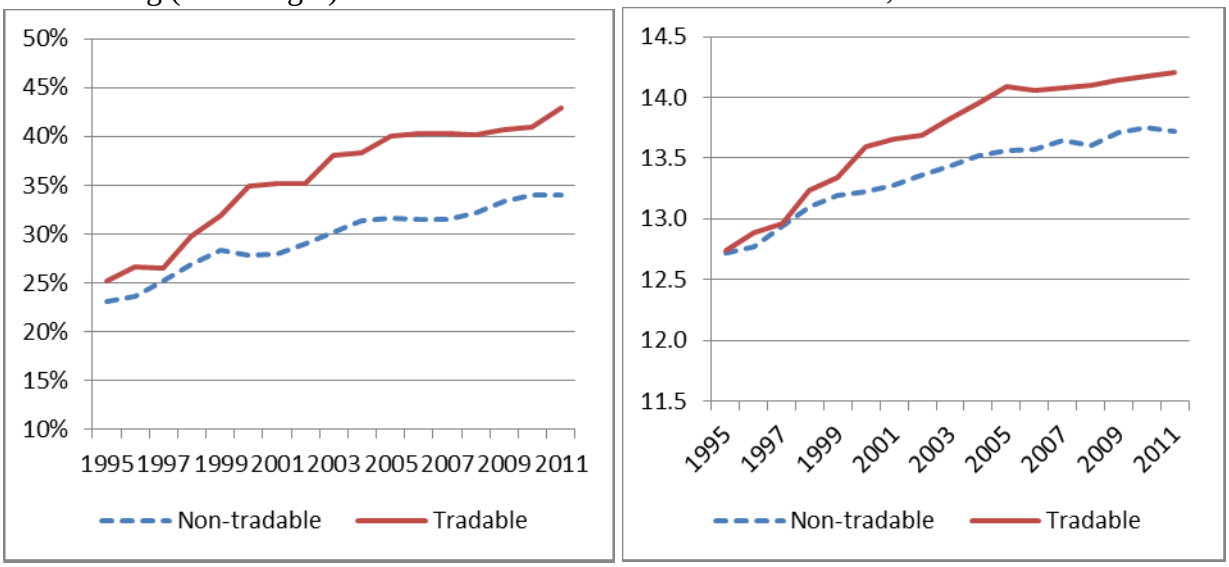
Source: OECD Education at a Glance 2013.
* Tertiary education with duration of at least three years full-time

Figure 3: Share of adults (25-64 year-olds) with higher education (on the left) and average years of schooling (on the right) in the tradable and non-tradable industries, 2011.



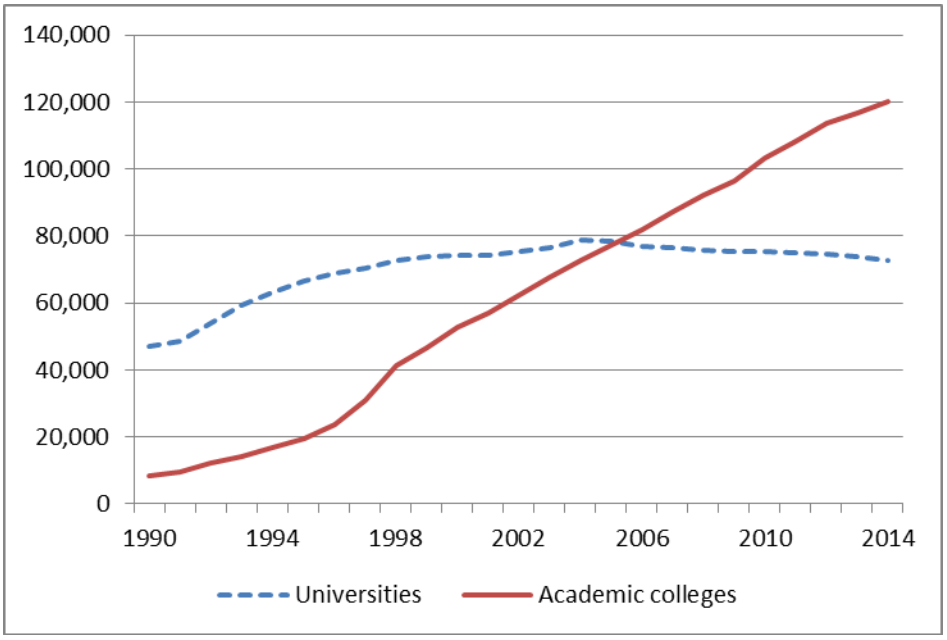
Source: The Israeli Central Bureau of Statistics

Figure 4: Share of adults (25-64 year-olds) with higher education (on the left) and average years of schooling (on the right) in the tradable and non-tradable industries, 1995-2011.



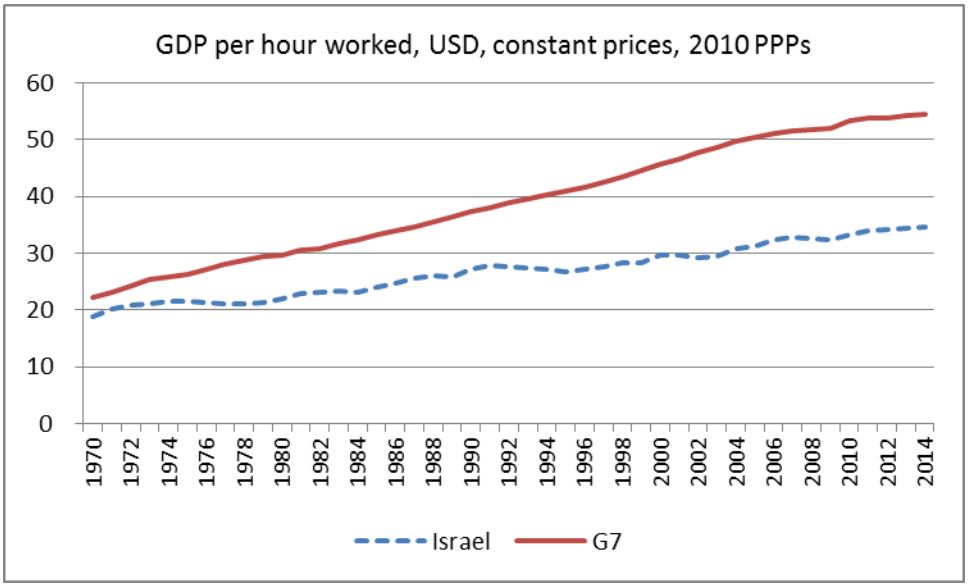
Source: The Israeli Central Bureau of Statistics.

Figure 5: Number of students enrolled in higher education for a bachelor's degree by type of academic institution



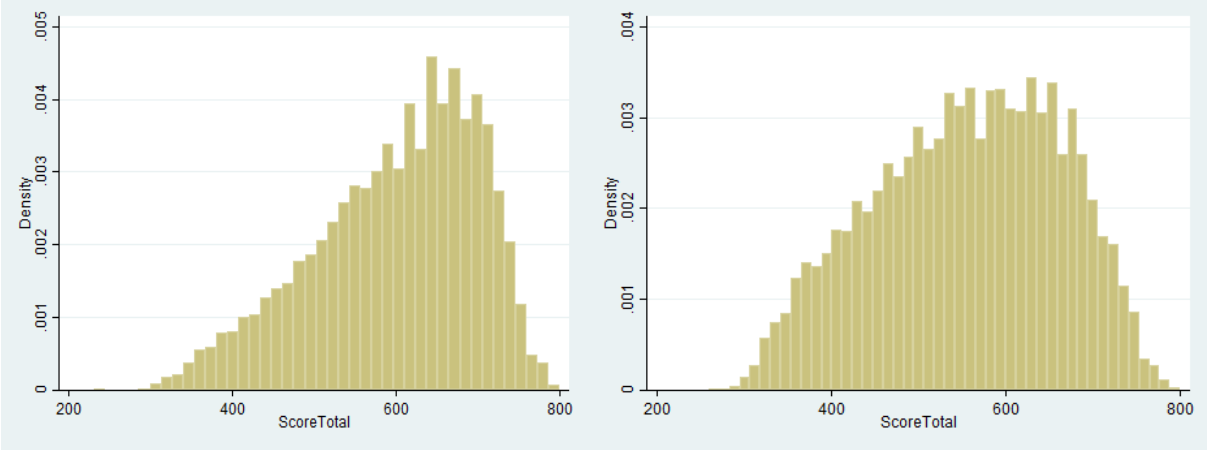
* Not including students at the Open University. For consistency in comparison, Ariel University (formerly Ariel College) is considered an academic college for all years.
Source: The Israeli Central Bureau of Statistics and the Taub Center.

Figure 6: GDP per hour worked in Israel and G7 countries. USD, constant prices, 2010 PPPs, 1970-2014.



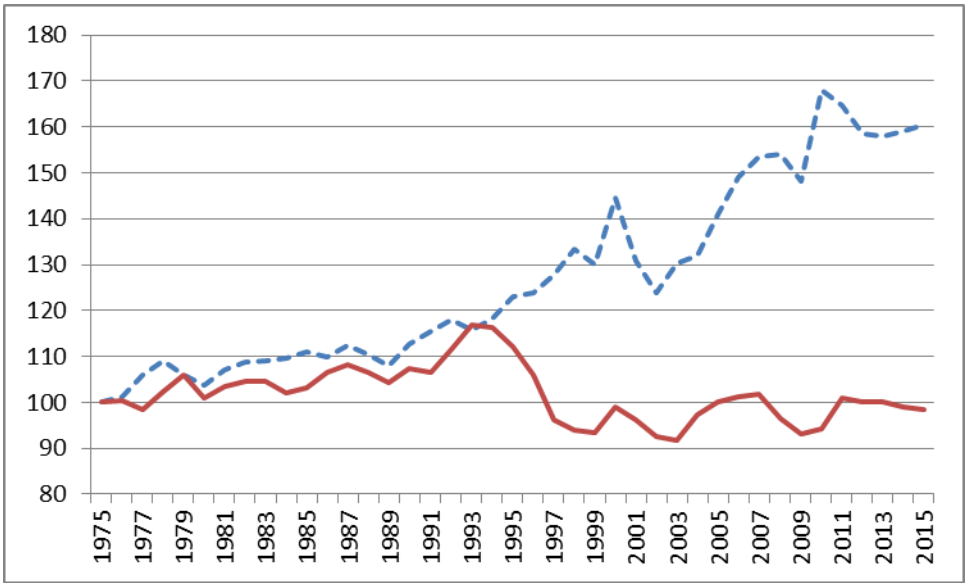
Source: OECD stat and the bank of Israel.

Figure 7: The distribution of the workers psychometric scores (equivalent to an SAT exam) in the tradable (on the left) and non-tradable industries (on the right)



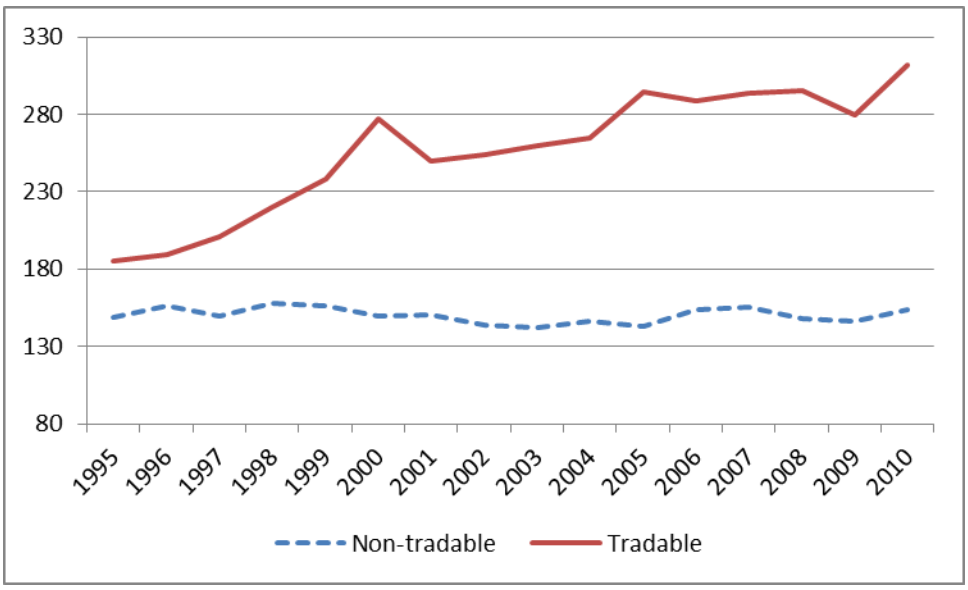
The data represents the year 2011 for workers in the age group 27-32 (n=68,664). The data was restricted to workers who completed at least an undergraduate degree and were employed at the time of the survey on a full time basis.
Source: The Israeli Central Bureau of Statistics.

Figure 8: Total Factor Productivity in the manufacturing industries and the trade and services industries, Index: 1975=100, 1975-2014.



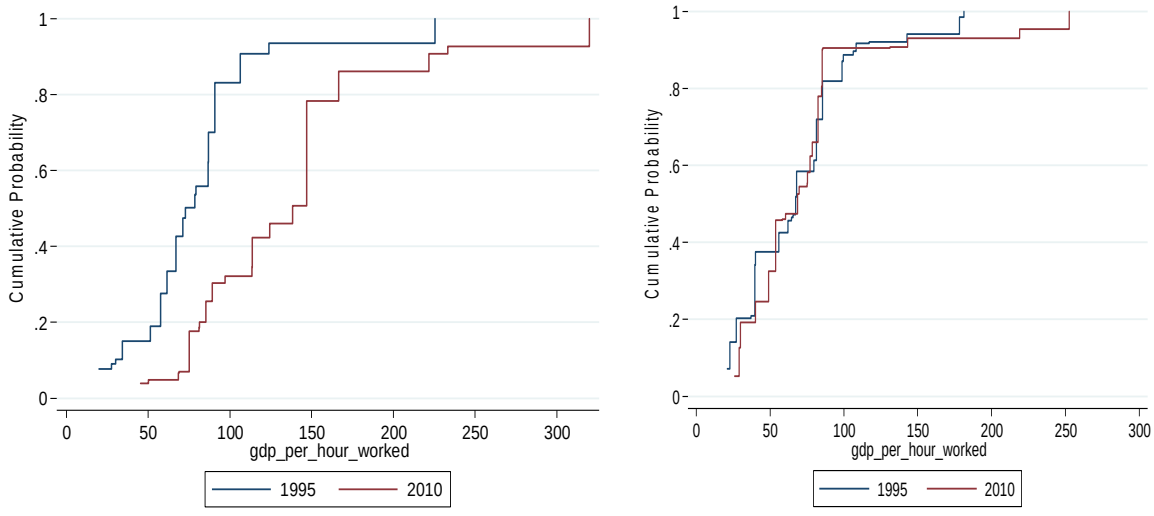
Source: The bank of Israel and the Taub center for social policy.

Figure 9: GDP per hour worked real growth in the tradable and non-tradable industries 1995-2010, NIS, constant prices, 2010.



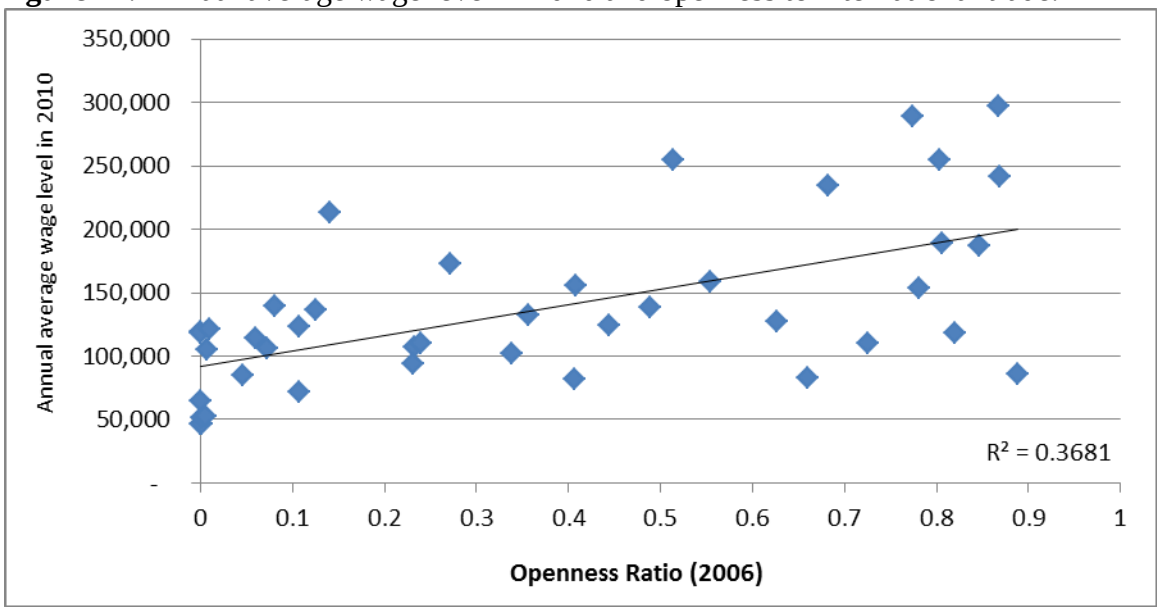
*Tradable industries were defined as industries in which their openness ratio exceeds>40%
** The index measures the share of exports and competitive imports within the total supply of the industry at the year 2006
Source: The Israeli Central Bureau of Statistics.

Figure 10: Cumulative distribution of productivity in 1995 and 2010 tradable (on the left) and non-tradable (on the right) industries.



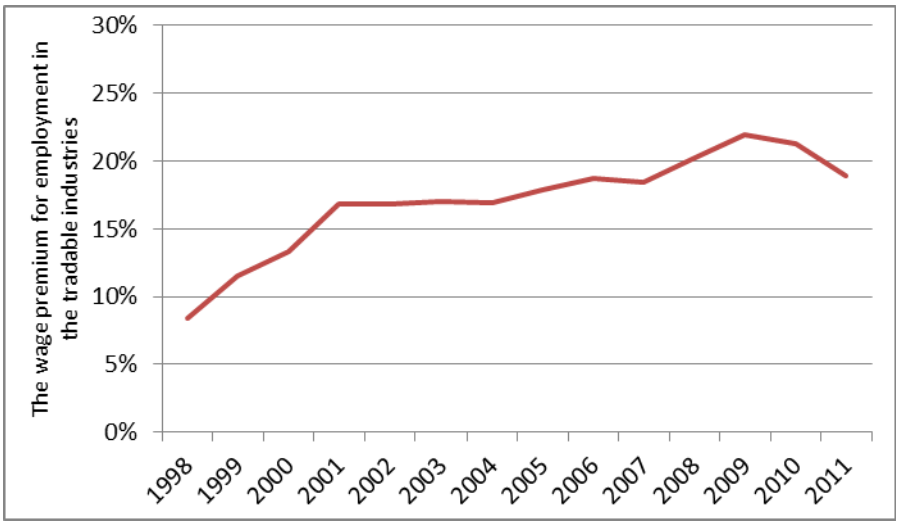
Source: The Israeli Central Bureau of Statistics.

Figure 11: Annual average wage level in 2010 and openness to international trade.



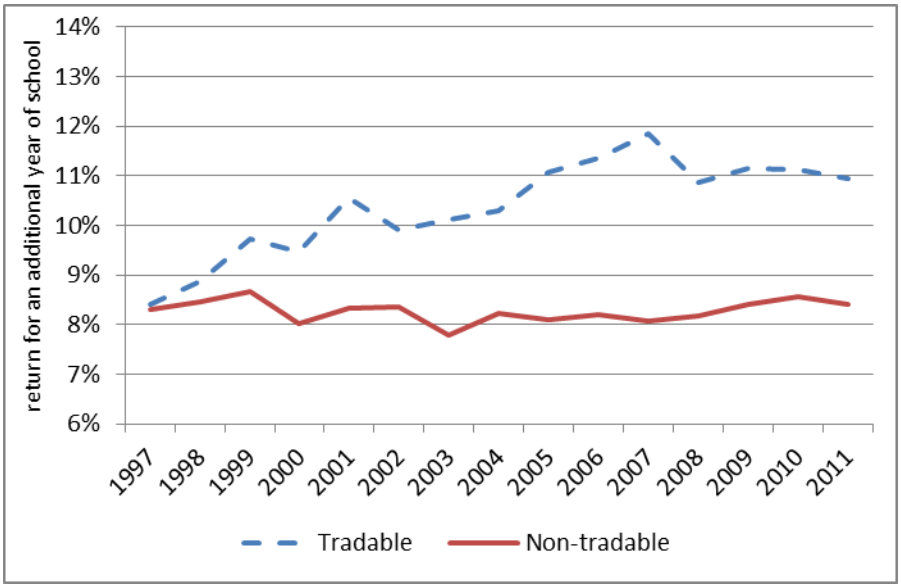
Source: The Israeli Central Bureau of Statistics.

Figure 12: The wage premium for employment in the tradable industries*



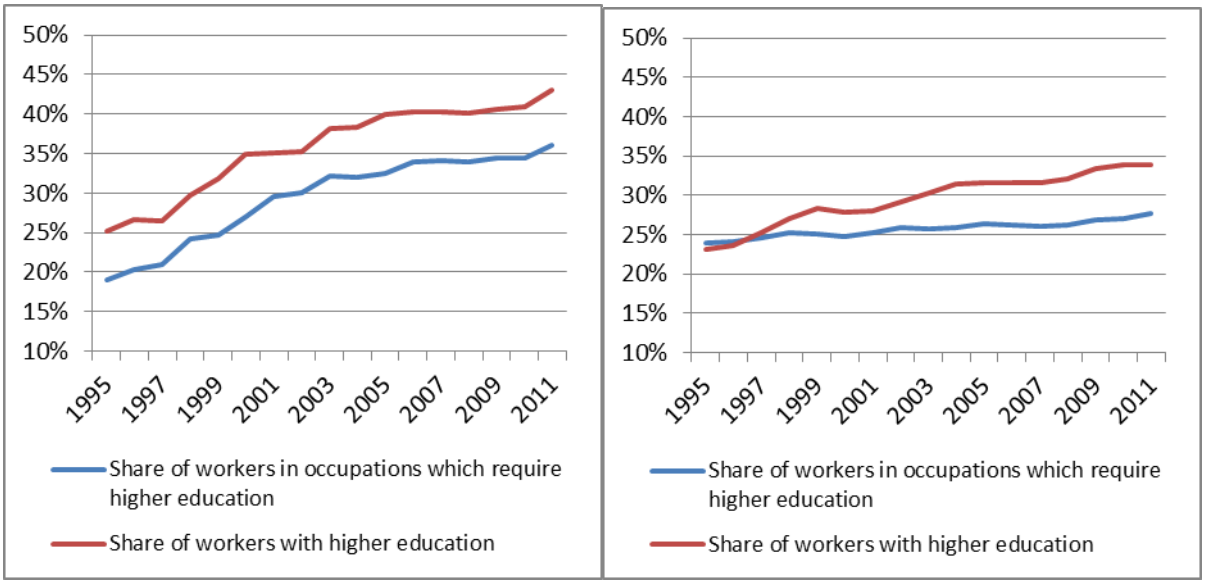
* 'The chart exhibits the wage differential between the tradable and non-tradable industries controlling for observable characteristics. The premium for employment in the tradable industries is estimated with the log hourly wage for full time workers (25-64 year-olds) regressed in each year on the following explanatory variables: potential experience and potential experience squared, years of schooling and years of schooling sqered, dummies for sex, immigrants and non-Jewish workers. A dummy for the tradable industries is added and a two year moving average of its coefficient shown in the figure.
Source: The Israeli Central Bureau of Statistics.

Figure 13: The college wage premium in the tradable and non-tradable industries 1995-2011*



* 'The college wage premium is estimated with the log hourly wage for full time workers (25-64 year-olds) regressed in each year on the following explanatory variables: potential experience and potential experience squared, years of schooling, dummies for sex, immigrants and non-Jewish workers. A dummy for the tradable industries is added, an interaction between the dummy and school years reveals the college wage premium in each industry group.
Source: The Israeli Central Bureau of Statistics.

Figure 14: Share of workers (25-64 year-olds) with higher education and the share of workers in occupations which require higher education. Tradable (on the left) and non-tradable (on the right) industries 1995-2011*



* According to the Central Bureau of Statistics classification (CBS – 1994) of occupations and the parallel international classification, occupations which require higher education are academic professions which include for example engineers, scientists, economists, and accountants (major group 0). Also included are associate professionals and technicians (major group 1) who include occupations that require tertiary education and not necessarily academic education.
Source: The Israeli Central Bureau of Statistics.

Table 1: Industry characteristics in 2010

Branch	GDP per hour worked	Average years of school	Employees (In thousands)	Openness ratio	Tradability
Storage, parking lots and freight terminals	85.86	12.25	5.4	0.00%	Non-Tradable
Hairdressing and beauty parlours	39.99	12.52	109.14	0.00%	Non-Tradable
Restaurants and dining services	29.12	12.29	137.77	0.00%	Non-Tradable
Postal and courier activities	75.17	12.98	13.28	0.00%	Non-Tradable
Labour recruitment and provision of personnel	26.04	14.93	92.77	0.10%	Non-Tradable
Security and cleaning activities	30.01	12.22	118.12	0.10%	Non-Tradable
Health services	49.02	15.11	161.45	0.60%	Non-Tradable
Motor vehicles, motorcycles and bicycles - sale, maintenance and repair and retail trade of fuel	77.06	12.2	64.45	0.70%	Non-Tradable
Education	84.82	15.53	40.68	1.00%	Non-Tradable
Recreational, cultural and sporting activities	75.37	14.3	56.66	4.60%	Non-Tradable
Land transport	68.77	11.6	78.49	6.00%	Non-Tradable
Publishing and printing	60.39	13.66	23.1	7.30%	Non-Tradable
Telecommunications	218.98	14.01	41.97	8.00%	Non-Tradable
Wholesale trade (excl. motor vehicles and motorcycles)	85.33	13.36	153.61	10.70%	Non-Tradable
Retail sale (excl. sales, maintenance and repair of motor vehicles)	53.79	12.59	226.86	10.70%	Non-Tradable
Insurance and social insurance funds	143.27	14.24	37.2	12.60%	Non-Tradable
Banking and other financial institutions	252.71	15.27	75	14.10%	Non-Tradable
Hotels and accommodation services	69.79	12.07	31.99	23.10%	Non-Tradable
Manufacture of food products	78.63	12.09	56.78	23.20%	Non-Tradable
Business activities n.e.c.	82.56	15.69	206	23.90%	Non-Tradable
Manufacture of soft and alcoholic beverages and tobacco products	131.29	13.45	4.43	27.10%	Non-Tradable
Manufacture of wood and wood products	58.22	11.41	4.94	33.80%	Non-Tradable
Manufacture of paper and paper products	84.99	12.06	9.65	35.60%	Non-Tradable
Manufacture of furniture	45.23	11.82	16.8	40.70%	Tradable
Manufacture of non-metallic mineral products	113.36	12.62	9.55	40.80%	Tradable
Manufacture of metal products (excl. machinery and equipment)	75.07	12.68	44.49	44.40%	Tradable
Manufacture of basic metal	81.28	12.33	6.07	48.80%	Tradable
Computer and related services	146.85	15.96	121.05	51.40%	Tradable
Auxiliary transport activities	113.6	13.82	35.94	55.40%	Tradable
Manufacture of plastic and rubber products	85.33	13.2	23.35	62.70%	Tradable
Manufacture of wearing apparel (except knitted)	50.2	12.78	4.34	66.00%	Tradable
Manufacture of refined petroleum and its products	319.87	13.9	31.27	68.20%	Tradable
Manufacturing n.e.c.	81.02	12.9	4.87	72.60%	Tradable
Manufacture of industrial equipment, medical and scientific equipment	166.46	15.4	33.58	77.40%	Tradable
Manufacture of electric motors and electric distribution apparatus	96.93	13.48	7.82	78.10%	Tradable
Air transport	233.24	14.78	8.8	80.40%	Tradable
Manufacture of electronic components	221.75	14.81	19.69	80.60%	Tradable
Manufacture of textiles	68.32	12.8	7.72	82.00%	Tradable
Manufacture of machinery and equipment	89.2	14.08	20.76	84.70%	Tradable
Manufacture of electronic communication equipment	124.34	15.21	15.93	86.70%	Tradable
Manufacture of transport equipment	138.43	13.6	20.11	86.90%	Tradable
Manufacture of footwear and leather products	68.73	11.62	1.77	88.80%	Tradable

Table 2: Psychometric test scores for workers in the tradable and non-tradable industries*

Sector	Obs	Mean	Std. Dev	Min	Max
Tradable	49,648	555.99	107.32	260	800
Non-Tradable	19,016	599.34	100.19	232	800
All	68,664	567.99	107.17	232	800

*The data represents the year 2011 for workers in the age group 27-32 (n=68,664). The data was restricted to workers who completed at least an undergraduate degree and were employed at the time of the survey on a full time basis.
Source: The Israeli Central Bureau of Statistics.

Table 3: Estimation results

Dependent variable annual growth rate in GDP per capita per hour worked, 1995-2015

	(1)	(2)	(3)	(4)	(5)
Log (GDP per hour worked in 1995)	-0.141	-0.107	-0.105		-0.098
	(0.053)***	(0.055)*	(0.52)**		(0.088)
Log (GDP per hour worked in 1995)^2	0.015	0.010	0.010		0.001
	(0.006)**	(0.006)	(0.006)		(0.010)
Log (school years in 1995)	-0.028	0.041		-0.041	0.064
	(0.0344)	(0.034)		(0.040)	(0.052)
Openness ratio	-0.169	0.052	0.053	-0.095	
	(0.0699)**	(0.007)***	(0.007)***	(0.099)	
Openness ratio X school years	0.017			0.012	
	(0.005)***			(0.007)	
Number of observations	42	42	42	42	42
R-squared	0.62	0.57	0.55	0.43	0.022

* p<0.1 ** p<0.05 ***<0.01

Average years of school are used for 25-64 year-olds. The Openness ratio measures the share of exports and competitive imports within the total supply of the industry in 2006. This measurement yields an index ranging from 0-1. The analysis is conducted on 42 non-mining/non-real-estate/non-agricultural/non-construction business sector industries**.** The dependent variable is the real annual growth rate in GDP per capita per hour worked during the years 1995-2010.

Table 4: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per hour worked in 1995	42	78.287	43.893	19.772	225.506
Openness ratio	42	0.367	0.319	0.000	0.888
school years in 1995	42	12.585	1.232	10.828	15.444
Openness ratio X school years	42	0.011	0.028	-0.046	0.064