

# Testing the Heckscher-Ohlin-Vanek Theory with a Natural Experiment

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## Abstract

This paper uses the historical episode of the near-elimination of commuting from the West Bank into Israel, which caused a large and rapid expansion of the local labor force in the West Bank, to test the predictions of the Heckscher-Ohlin-Vanek (HOV) model of trade. I use variation between districts in the West Bank to test these predictions, and find strong support for them: Wage changes were not correlated with the size of the shock to the district labor force (Factor Price Insensitivity); Districts that received larger influx of returning commuters shifted production more towards labor intensive industries (Rybczynski effect); And on the consumption side, the data are consistent with the assumption of identical homothetic preferences, which, combined with the production results, supports the Heckscher-Ohlin-Vanek theorem on the factor content of trade.

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# 1 Introduction

According to the Heckscher-Ohlin theory, all else equal, countries will tend to export those goods whose production is intensive in the factors they have in relative abundance. One of the most important formulations of this insight, the Heckscher-Ohlin-Vanek theorem, states this result in terms of the so-called “factors content of trade”: Countries will be net exporters of the services of factors they have in relative abundance, embodied in the goods they trade. The theoretical appeal of the HOV framework has made it one of the pillars of neo-classical international trade theory. However, the long history of its empirical tests gives the theory little, if any, support. As Davis and Weinstein (2001) put it in an important paper: “The prediction [of the HOV theorem] is elegant, intuitive, and spectacularly at odds with the data”. An important reason for these empirical failures of the theory is that the ‘all else equal’ assumption in the HOV theory is a very strong one indeed. It includes, most notably, the assumptions that all countries have identical technology and identical preferences, and so - identical factor prices, which is clearly rejected by the data. Accordingly, most of the modifications that were introduced into the theory in order to reconcile it with observed trade flows revolved around replacing these assumptions with more general ones, allowing, for example, technological differences, preferences differences, trade costs, and so on.

In this paper, I take a different approach. Instead of using the theory to explain trade data in a cross-section of countries, where the ‘all else equal’ assumption seems problematic, I use it to explain changes in production and trade patterns in a number of small open economies, following a large, exogenous, and persistent shock to their relative factor abundance. The use of this “natural experiment” allows me to test the core of the HOV theory, without having to introduce any new assumptions. It is, to my knowledge, the first paper to test the HOV formulation of the Heckscher-Ohlin insights using a natural experiment. The results are encouraging for the theory: All three of the relevant predictions of the HOV framework, i.e. Factor Price Indifference, the Rybczynski effect, and the HOV theorem, are supported by the data.

The historical episode I use in this study is the near elimination of commuting from the West Bank into Israel in the year 2000. Until that point around 20% of the labor force in the West Bank commuted to work in Israel on a daily basis. In October 2000, following the outbreak of the Second Intifada, the number of commuters to Israel was severely restricted by the Israeli government, and remained low since. The immediate result of this policy change was a large increase in the effective size of the domestic labor force available for work in the West Bank, making the West Bank substantially more labor abundant. Two important features of this historical episode make it especially suitable for testing the predictions of the HOV model. First, throughout the whole period in question, while the movement of people across the border was severely restricted, the movement of goods was not, and the West Bank traded extensively with the world. Second, large variation in commuting patterns between the different districts of the West Bank before 2000 led to substantial variation in the size of the shock to their labor force when commuting declined. Moreover, the data show that due to extremely limited mobility between districts, the variation in the size of the initial shock had a persistent effect on the size of the labor force in each district. It is this variation that I use to test the predictions of the HOV theory.

In the West Bank context, comparing a district which received a large influx of returning commuters to one which received a smaller influx, the HOV theory makes three major predictions: First, the Rybczynski effect predicts that a district which received a larger influx of returning commuters will experience a larger shift of its production towards labor intensive industries. Second, the Factor Price Insensitivity (FPI) result predicts that such a district will *not* experience slower wage growth, in spite of the larger increase in labor supply. And third, the HOV theorem predicts that a district that received a larger influx of returning workers will increase its net exports of labor services, embodied in labor intensive goods, more than a district which received a smaller influx. The first two predictions (Rybczynski effect and FPI) are directly confirmed by the data. Unfortunately, since no data on “imports” and “exports” of districts in the West Bank exist, the third prediction cannot be tested di-

rectly. However, it is supported indirectly by data on consumption patterns. Put together, these results provide substantial empirical support for the HOV theory.

What use, however, is a test of the HOV theory, a theory of trade between real countries, that instead of explicitly modeling the real differences between countries, finds a way around these differences? To answer this question, one needs first to explain what use is the HOV theory to begin with. The HOV model, if true, can be used for two different purposes. It can explain observed global trade patterns based on global relative factor endowments, and it can predict the effects that various shocks in an open economy — to terms of trade, to factor endowments, etc. — will have on domestic factor markets and on trade patterns. Most of the literature showed that the basic model performs the former task poorly, and tried to elaborate on the theory to make it more compatible with observed trade flows. This paper shows that even in its most basic version, the HOV model performs the latter task well.

## 2 Relation to the Literature

This paper contributes to the large literature on empirical tests of the HOV model. Essentially all of this literature, dating back to the famous “paradox” discovered by Leontief (1953), and including the seminal work of Stern and Maskus (1981), Maskus (1985), Bowen, Leamer, and Sveikauskas (1987), and Harrigan (1995), find that the theory, at least in its most basic form, does very poorly in predicting trade patterns. Later work, such as Treffer (1993), Treffer (1995), and Davis and Weinstein (2001), therefore, focused on documenting the ways in which observed trade patterns deviate systematically from those predicted by the HOV theory, and suggested modifications to the theory, such as productivity differences between countries, home bias in consumption, trade costs, and the existence of non-tradeable goods, which greatly improved the predictive power of the model. The main contribution of this paper is that instead of expanding the theory by adding and relaxing assumptions to make it more compatible with observed international trade data, I use an historical

episode where the ‘all else equal’ assumption of the HOV model is plausible, but nonetheless the model makes non-trivial predictions.

Bernhofen and Brown (2011) use the natural experiment of Japan’s move from autarky to free trade in the mid-nineteenth century to test what they refer to, following Deardorff (1982), as the general validity of the Heckscher-Ohlin model, or HOD (Heckscher-Ohlin-Deardorff). Relying on numerous sources for factor prices and production techniques, they find empirical support for the main testable prediction of the HOD, which states that evaluated at factor’s autarky prices, the value of the factor content of trade is (weakly) positive. In addition to using more standardized data, from a more recent historical episode, the contribution of this paper relative to Bernhofen and Brown (2011) is that it tests one of the most special versions of the Heckscher-Ohlin model, maintaining all the strong assumptions of the HOV formulation, and not the most general formulation, and therefore it yields very stark results.

Of all the empirical work on the HOV model, this paper is most closely related to Davis, Weinstein, Bradford, and Shampo (1997), who, like I do in this paper, use data on different regions within one country (prefectures in Japan in their case) to test the predictions of the HOV model for production and for consumption, and find that applying the theory to Japanese prefectures does a very good job in explaining production patterns in Japan. However, using data on different regions in the same territory to test the HOV model raises the issue of the mobility of factors as an alternative explanation for the findings, and thus of interpreting correlations as causality: did labor flow into districts with industries that are labor intensive, or did districts with large labor endowment specialize in labor intensive sectors? Were wages equalized by the migration of labor to areas with higher labor demand, or by the migration of labor intensive industries to areas with high labor supply? Davis, Weinstein, Bradford, and Shampo (1997) argue that this “poses no fundamental problem” since “the Heckscher-Ohlin relations must hold *ex post*”, and this is certainly true. The contribution of this paper is that the natural experiment I consider does not restrict itself to *ex-post* statements, but directly demonstrates causality: labor did not flow into regions in the West Bank with labor intensive industries, but

rather regions that received, for exogenous reasons, a larger influx of labor, shifted their production more towards labor intensive industries, and exported the increased production of these goods. Another contribution of this paper has to do with the interpretation of the results. A well known issue with some of the empirical literature on the HOV model is that in the absence of a clear alternative theory, it is not obvious how to interpret the results of some of the tests. In particular, a common measure that is used in the literature is the correlation between the predicted values of some variable, and their actual values. However, what magnitude of this correlation should be considered a “success” of the theory? In many tests, just the fact the correlation is positive, and significantly different from zero, means little. As Davis, Weinstein, Bradford, and Shimpo (1997) explain: “Setting a null that there should be no correlation... could be rejected in most cases, but little comfort can be obtained by rejecting such an absurd proposition”. In this paper, I create a counter-factual West Bank, that shares many important features with the real West Bank, but in which sectoral changes in the composition of production do not occur, and therefore the HOV theory, by construction, has no explanatory power. I then use this counter-factual economy as a benchmark against which to evaluate the results of the tests of the HOV model in the real data. This exercise further underscores the success of the HOV predictions in the West Bank.

This paper is also related to the work of Gandal, Hanson, and Slaughter (2004), that performed “absorption accounting” for the way the immigration wave from the USSR into Israel in the 90’s was absorbed into the labor market. They find that changes in Israel output mix did not play a role in absorbing the changes in the size and skill composition of the labor force in Israel. However, lacking a valid counterfactual, they caution against interpreting their findings as causal, and argue that they should only be understood as an accounting of the relative contribution of different elements (local technological change, output mix change, etc.) to the absorption of the new immigrants into the labor market. Hanson and Slaughter (1999) use a similar methodology to analyze output mix changes in the U.S. in response to immigration waves, and

find the output mix changes “broadly match state endowment change”, and that relative FPE holds, which provide indirect support for the output mix change hypothesis. Relative to these studies, the West Bank experience after 2000 provides a much larger change in the size of labor markets, with a more plausibly exogenous source of variation. This allows for sharper tests of the theory, and accordingly, I find that output mix change not only broadly matches changes in labor supply, but it can explain, quantitatively, the absorption of the returning commuters.

This paper contributes also to the very large literature on the effects of immigration on labor markets (see Kerr and Kerr (2011) for a recent survey of the literature). While the historical context of this paper is different from that of most immigration waves, since most of the workers who commuted into Israel before 2000 have been and remained residents of the West Bank, by highlighting changes to the output mix as a way to absorb new workers into the labor market, this paper can help explain why some studies, such as Card (1990), found little effect of immigrants on the wages of natives.

Last, but not least, this paper can help in understanding labor markets and their relationship with trade in the West Bank, and the interaction of both with the political conflict - a topic of importance for policy. Several studies, such as Angrist (1995), Angrist (1996), Etkes (2011), Flaig, Siddig, Grethe, Luckmann, and McDonald (2013), and Mansour (2010) have looked at the relatively short run effects of Israeli policies on Palestinian labor markets. This is the first paper to study the long run effects of the decline in commuting into Israel, and the first to directly relate labor market conditions in the West Bank to trade.

The rest of the paper is organized as follows: Section 3 describes the historical episode that is used in the paper, and explains what makes it suitable for testing the HOV theory. Section 4 derives the testable predictions of the HOV model that will be tested using the data from the West Bank, and reports the results of these tests, and section 5 concludes. The data I used to compile the variables for this study, and the way they were compiled, is described in the data appendix.

## 3 Historical Background

### 3.1 The West Bank Labor Force

Work commute by Palestinians from the West Bank into Israel began almost immediately after the Israeli capture of the West Bank from Jordan in 1967 (See Angrist (1995)), and during the late 1990's, about 20% of the labor force in the West Bank commuted to work in Israel on a daily or weekly basis, most of them using travel permits issued by Israel (see Etkes (2011) for institutional details). In September 2000, a wave of violent clashes between Israeli forces and Palestinian protestors, later known as the Second Intifada<sup>1</sup>, erupted, and quickly escalated from mass demonstrations to a wave of suicide terrorism and counter attacks by Israel. As a result, Israel's permits policy changed markedly, and security measures at the border increased, resulting in a very large, and, at least so far, permanent drop in the number of commuters into Israel. Figure 1 shows the effects of this change on the Palestinian labor market in the West Bank. From a peak of over 20% in the first three quarters of 2000, the share of commuters out of the total labor force in the West Bank dropped to less than 5%, and remained below 7.5% since. The immediate effect of the substantial decline in the number of commuters was a drop in employment rates from around 75% in 1999 to below 60%. However, by 2007 (marked by a dashed line in the figure) employment rates mostly recovered, though to a somewhat lower level, and it seems reasonable to treat 2007 as the end of the recession in the West Bank. This study therefore focuses on the period between 1999 and 2007.<sup>2</sup>

A key fact about the commuting patterns in the West Bank was the variation between the 10 districts that comprise the West Bank. Table I reports the share of commuters to Israel by district in 1999, which ranges from 11.7% for Nablus to 35.7% in Salfit. The reason for this variation is mostly geographic.

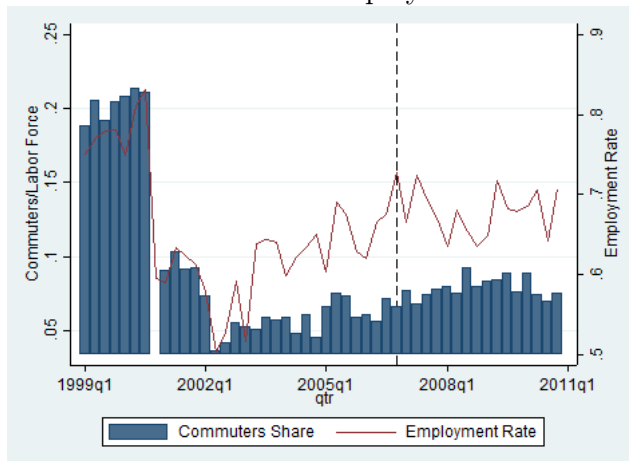
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<sup>1</sup>The first Intifada being the one in 1987

<sup>2</sup>Another reason for using two odd years, 1999 and 2007, is to avoid problems related to the bi-annual seasonality of the olives industry, which is a non-negligible part of the West Bank economy



Figure 1: Commuters to Israel and Employment Rate in the West Bank



Notes: Data is at a quarterly frequency and is taken from the Palestinian Central Bureau of Statistics Labor Force Survey. Commute to Israel is as reported by workers to Palestinians surveyors. Share of commuters is the number of persons who live in the West Bank and report commuting to work in Israel out of total persons who live in the West Bank and participate in the labor force. Employment rate is total employed persons divided by all persons in prime working age (25-55).

Miaari, Zussman, and Zussman (2012) use Israeli administrative data about work permits issued to Palestinians to analyze commuting patterns at the locality level, and find that distance from Israel has a large and highly significant negative effect on the prevalence of commuting into Israel. The only other variable they report to have an effect is the type of locality, with villagers commuting slightly more than city dwellers.

This large variation in the commuting patterns in the years before the Second Intifada means that the immediate shock to the local labor force differed substantially between districts. However, for the purposes of this study it is necessary that the initial shock had a persistent effect on the size of the labor force in each district. Data from the Palestinian Migration Survey, conducted by the Palestinian Central Bureau of Statistics, suggests that this is indeed the case: Migration between districts in the West Bank was extremely limited: in 2010, 95.3% of the population in the West Bank resided in the same district where they were born. The breakdown of these numbers by district

Table I: Commuters to Israel in 1999, by District of Residence

	Share of Commuters out of Total Labor Force
Nablus	11.7%
Ramallah	12.9%
Bet Lehem	15.4%
Jericho	20.2%
Tulkarm	20.3%
Tubas	22.3%
Hebron	24.4%
Qalqilya	24.6%
Jenin	27.4%
Salfit	35.7%

Notes: Data is taken from the Palestinian Central Bureau of Statistics Labor Force Survey. Commute to Israel is as reported by workers. Share of commuters is the number of persons who live in a district and report commuting to work in Israel out of total persons who live in the district and participate in the labor force.

is reported in table II. In all but one district, Jericho,<sup>3</sup> the share of residents who were born in the district is between 92.9% and 97.0%. Moreover, only 7.6% of movers reported to have moved for work related reasons,<sup>4</sup> making the size of internal migration motivated by labor market considerations extremely small, and it is therefore likely that the initial shock caused by the Israeli policy change in 2000 had a persistent effect.

Figure 2, which plots the share of the labor force in each district that used to

<sup>3</sup>The share of non-natives in Jericho, at 34%, is hard to explain, and might be a measurement error. One possible explanation is that Jericho was the first city in the West Bank to be handed over to the Palestinian Authority in 1994, and may have attracted some internal migration as a result. At any rate, given the very low share of movers that move for work reasons, even for Jericho the number of residences who moved there for work purposes is fairly small.

<sup>4</sup>The leading reason for migration is marriage to a person from another district.

Table II: Internal Migration in the West Bank

	% of District Residences, Born in the Same District
Jenin	97.0
Tulkarm	95.0
Nablus	94.9
Qalqilya	96.7
Salfit	95.6
Tubas	92.9
Ramallah	95.8
Jericho	66.1
Bet Lehem	97.0
Hebron	96.1

Notes: Data is from the Palestinian Central Bureau of Statistics Migration Survey.

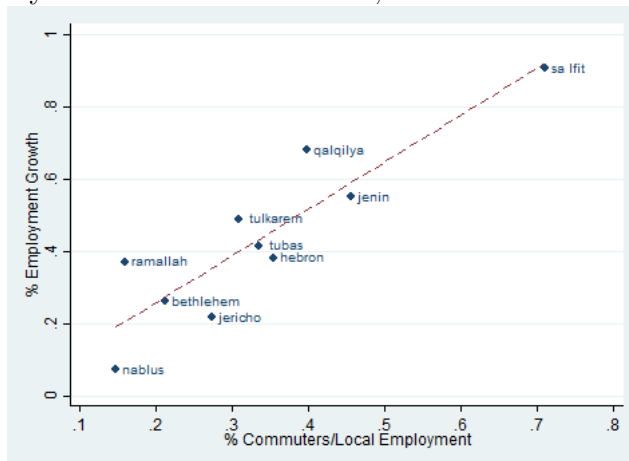
commute to Israel against the growth in the number of workers in each district following the decline in commuting, addresses this issue directly. As can be seen, the growth in the number of employed persons in each district in the years following the return of the commuters (1999-2007) is very strongly correlated with the share of commuters in that district in 1999. A linear regression of the percentage employment growth on commuters to local workers ratio<sup>5</sup> (and no other regressors) yields an R-square of 0.79, suggesting that the variation in commuting patterns explains a large part of the variation in employment growth over the years following the initial shock.<sup>6</sup>

Nor did workers in the West Bank increase their commuting to other districts within the West Bank. In 1999, 6.1% of employed persons in the West

<sup>5</sup>This ratio is the the growth in employment that will result from adding returning commuters to local employment

<sup>6</sup>The same calculation for total labor force instead of employed persons gives similar results.

Figure 2: Employment Growth 1999-2007, and Share of Commuters in 1999



Notes: Data is based on the Palestinian Central Bureau of Statistics Labor Force Survey. Commute to Israel is as reported by workers. Growth in employment is calculated as the number of employed persons in 2007 divided by their number in 1999.

Bank were commuting to work in a district where they did not live, and in 2007 the number actually dropped somewhat, to 5.6%. These findings are consistent with previous studies which focused on the short run effects of Israeli policy, such as Mansour (2010), who argues that the labor supply shocks following the decline in commuting to Israel were absorbed locally, because of Israeli restrictions on movements of people within the West Bank. While this low mobility may be surprising, considering the very high mobility that is demonstrated in the large share of commuters into Israel before 2000, it is important to remember that the wage premium for working in Israel was much higher than for commuting within the West Bank (see for example Angrist (1995)). At any rate, be the reason for low mobility within West Bank what it may, the evidence suggest that mobility between districts was very low, and that the return of the Palestinian commuters to the West Bank had a persistent effect on the size of the labor force in the different districts. It is the variation between districts in the size of the shock to their local labor force that is the key to my empirical analysis.

Were commuters similar to workers who did not commute? If there were

important differences between commuters and stayers, it would suggest that the shock was not a single shock to aggregate labor supply, but a number of potentially different shocks to different kinds of labor. Indeed, in 1999, commuters were different from staying workers along a few dimensions: they were a bit younger (average age of 31.6 of commuters, and 34.8 for stayers), more likely to be from a rural locality (59.1% of commuters were from rural localities, 42.3% of stayers), and essentially all men (98.1% of commuters, relative to 76% of stayers). Importantly, they also had, on average, one year less of formal education (10 years for stayers, 9.1 years for commuters), and a much lower share of commuters had a college degree (14.2% of stayers, 1.5% for commuters). These numbers suggest that commuters may have been less skilled than the average worker in the West Bank who did not commute. To gauge how important were these differences, I compare the actual mean wage of stayers in each district in the West Bank with the mean predicted wage of commuters from that districts, based on their observable characteristics, had they not commuted. Technically, I do so by regressing wages of staying workers on age, age square, sex, years of formal schooling, type of locality, and district dummy, and based on the coefficients obtained from this regression, I predict the wages of commuters in each district had they not commute. Table III reports the results of this procedure. When using the full sample of workers (columns 1-3), the mean wage predicted for commuters, based on their observables, is, on average, 6.6% lower than that of stayers. This difference is also seen at the district level, and the difference is statistically significant at the 5% level in six of the nine districts. However, When workers with academic degrees are removed from the sample (columns 4-6), commuters' mean predicted wage throughout the West Bank is essentially identical to that of stayers, with a difference of less than 1%. When the data is broken down by district, there is a small difference in favor of commuters, though it is only statistically significant in three districts, and generally very small. While these considerations suggest that commuters were more similar to the non-college educated workers in the West Bank than to the labor force as a whole, if there was any positive selection into commuting, which seem highly likely,

commuters' predicted wage, based on observables, may understate their true skill level. I therefore perform all the tests in this paper both for aggregate labor, and, separately, for low skill workers. The results are equally supportive of the HOV predictions in both specifications.

Table III: Wages of Stayers and Predicted Wages of Commuters in 1999

	Full Sample			Excluding Workers with College Degree		
	Actual Wage - Stayers (1)	Predicted Wage - Commuters (2)	P-value for Difference>0 (3)	Actual Wage - Stayers (4)	Predicted Wage - Commuters (5)	P-value for Difference≠0 (6)
Whole West Bank	63.3	59.6	<0.01	58.7	58.2	0.33
Jenin	59.2	56.4	0.02	53.7	54.8	0.36
Tulkarm	56.4	54.2	0.12	49.8	51.8	0.20
Nablus	58.7	55.6	0.04	51.5	55.0	0.04
Qalqilya	55.6	52.8	0.05	47.9	52.3	0.01
Salfit(Tubas)	57.5	54.1	<0.01	53.0	53.4	0.73
Ramallah	73.7	71.3	0.29	66.3	70.3	0.01
Jericho	58.2	52.7	<0.01	55.0	51.8	0.06
Bet Lehem	74.1	71.4	0.18	68.2	70.5	0.15
Hebron	62.4	60.5	<0.01	59.6	59.5	0.98

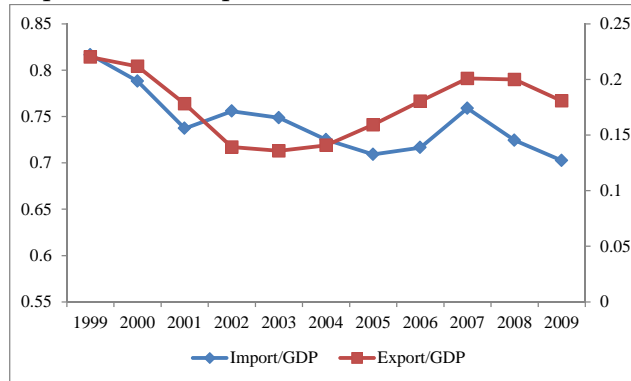
Notes: Data is based on the Palestinian Central Bureau of Statistics Labor Force Survey. Commute to Israel is as reported by workers. Predicted wage for commuters is calculated based on a wage regression using the sample of workers who live and work in the West Bank, and applying the coefficients from this regression to the commuters in each district.

### 3.2 Trade in Goods and Services in the West bank

While the movement of workers into Israel was severely restricted, the movement of goods was not, and throughout essentially all of the period in question the West Bank traded extensively. Figure 3 shows imports and exports for the West Bank for the period 1999-2009. The West Bank, like some other developing economies, was and is running a very large trade deficit, equal to about 60% GDP, funded mostly with large transfers from donating foreign governments and NGO's, and remittances of Palestinians working abroad. The deep

recession in the years immediately after the outbreak of the Second Intifada is evident in the trade data. In later years, while exports recovered, imports did not, declining from 82% of GDP in 1999 to around 72% of GDP towards the end of the decade. The larger decline in imports relative to exports is likely at least in part because of the decline in commuting, which funded some of the trade deficit. The importance, or lack thereof, of these changes in trade shares is discussed in detail in section 4, but what is clear, and is key to the analysis, is that the West Bank was open to trade, and indeed traded extensively throughout the whole period in question.

Figure 3: Imports and Exports as Share of GDP in the West Bank



Notes: Data is from the Palestinian National Accounts. Imports on the left axis, and exports on the right axis.

## 4 The Predictions of the HOV Model for the West Bank

In its simplest form, the HOV model states that if all countries have access to the same technology,<sup>7</sup> and have identical homothetic preferences, but have endowments with different ratios between factors of production, then they will tend to export those goods that use their abundant factors intensively. This

<sup>7</sup>Technology here means a set of possible techniques. A technique is a specific mix of inputs per unit of output.

is often stated in terms of the factor content of consumption, production, and trade. First, under free and costless trade, and assuming all countries produce all goods, and have access to the same technology, factor prices will be equalized. Then, if all countries consume all factors, embodied in goods, in the same proportions (due to identical homothetic preferences), but different countries are endowed with different factor proportions, then the difference between the uniformity of consumption ratios, and heterogeneity in endowments ratios, is the factor content of trade.

In the context of the West Bank, the HOV model predicts that, comparing two districts, a larger increase in the size of the labor force will not be absorbed through slower wage growth, and the implementation of more labor intensive techniques, but by a larger shift in the composition of production towards more labor intensive industries, using the same techniques. Moreover, due to identical homothetic preferences, the change in the composition of production will not be absorbed through increased consumption of labor intensive goods in the district, but through changes in the factor content of trade between districts. Lastly, since the increased production of labor intensive goods is “exported”, the prices of these goods do not fall (relative to their prices in other districts), and so the Stolper-Samuelson effect is avoided, and wages do not decline (relative to wages in other districts). In this section, I show evidence that support all of these propositions.

## 4.1 The Composition of Production

I turn now to derive the precise predictions of the HOV model that can be tested using data from the West Bank before and after the decline in commuting, using district level data on gross output and employment for 15 sectors, which comprise essentially all of the West Bank output.<sup>8</sup> Following standard notation, let  $X_i^t$  be the  $15 \times 1$  vector of gross output in each sector in district  $i$  in year  $t$ , let  $B_i^t$  be the  $M \times 15$  matrix of cost minimizing direct inputs needed

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<sup>8</sup>The 15 sectors correspond to the upper level structure of the ISIC Rev.4 classification system, minus two sectors: the financial sector, for which no data is available, and Mining and Quarrying, which is very small, and is present in only 2 districts.



to produce one unit of each good in district  $i$  in year  $t$  ( $M$  being the number of factors of production), and let  $V_i^t$  be the  $M \times 1$  vector of factor endowments in district  $i$  in year  $t$ . The HOV theory of production predicts that all districts will use the same technique, that is, that  $B_i^t = B^t \forall i, t$ . Thus, the HOV model predicts the following relationship between technology, output, and the factor endowment of each district:

$$B^t X_i^t = V_i^t$$

Note that this is not a trivial full employment condition. It states that full employment will be achieved in all districts by using the same production technique, ruling out the possibility that labor abundant districts will employ more labor intensive techniques to achieve full employment. Suppose now that for whatever reason, some districts deviate from this relationship, say because they have higher labor productivity than others. In this case, the HOV model of production can be written as:

$$B^t X_i^t = V_i^t + \epsilon_i \tag{1}$$

where  $\epsilon_i$  represents any consideration that may cause a district to systematically deviate from the prediction of the HOV model. Of course, I do not introduce a district and time specific deviation, as this will devoid the theory of any empirical content. Presenting the theory this way also makes clear what are the advantages of using a natural experiment. Much of the work on expanding the HOV model to make it more compatible with the cross-section data focused on making explicit assumptions about the nature of  $\epsilon_i$ . I, in contrast, address these potential deviations from the basic model by first taking the difference of 1 between two districts, which yields:

$$B^t(X_i^t - X_j^t) = (V_i^t + \epsilon_i) - (V_j^t + \epsilon_j) \tag{2}$$

and then taking the difference of 2 between  $t = 0$  and  $t = 1$ , which after

some rearranging, yields:

$$B^1(X_i^1 - X_j^1) - B^0(X_i^0 - X_j^0) = (V_i^1 - V_i^0) - (V_j^1 - V_j^0) \quad (3)$$

which is the prediction to be tested using the data on production from the West Bank. I call the RHS the *relative supply shock*, and the LHS the *imputed relative demand change*, where both demand and supply here refer to the factors market.<sup>9</sup> The RHS is simply the difference in the size of the shock to the factor endowment between district  $i$  and district  $j$ . The LHS is the difference between the two districts in the change to demand for factors that can be inferred from the observed change in output. Equation 3 will only hold in the data if districts absorbed larger influxes of labor by changing their output mix, and not if increase in labor endowment was absorbed by shifting to more labor intensive techniques.

This empirical strategy, like all natural experiments, has a clear intuitive sense. Instead of assuming that districts share the same technologies, or explicitly modeling the differences between them, the natural experiment allows me to “difference out” these differences. I Compare a district from before the shock to its factor endowment, to itself after it, in each case, using other districts to control for time variations that are common to all districts in the West Bank.

Since the test is defined over pairs of districts, using 9 districts<sup>10</sup> yields, for every factor of production, 36 predictions (one for each unordered pair), though only 8 of them are completely independent of each other. The results of these tests are encouraging to the theory. Figure 4 plots the results of the tests for aggregate labor when using all unordered pairs, and figure 5 plots the results using Nablus as the base against which all district are compared.<sup>11</sup> Each

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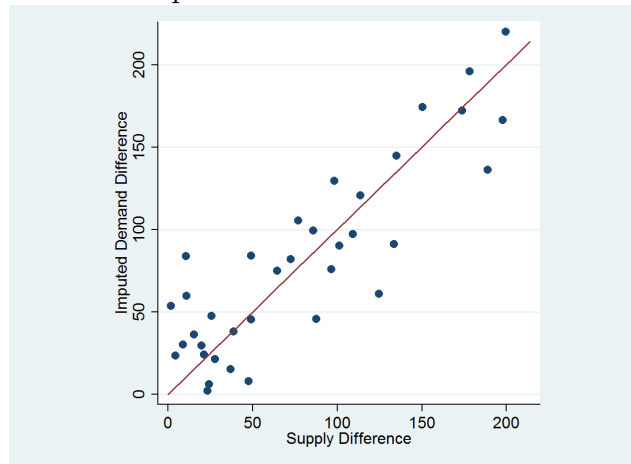
<sup>9</sup>Davis, Weinstein, Bradford, and Shimpo (1997) call the equivalent of the RHS the *observed* endowment, and the LHS the *predicted* endowment, i.e. the endowment that is predicted by the HOV model, given the observed patterns of production.

<sup>10</sup>I combine Tubas and Salfit, the two smallest districts, into one artificial district. Not doing so can raise sample size problems.

<sup>11</sup>Results are all in absolute value. Not using the absolute value of the RHS and LHS makes the test look much better than when using absolute values. Since the test gets the

point is a pair of districts, with the relative supply shocks on the horizontal axis, and the imputed relative demand change on the vertical axis. If the HOV model predictions held perfectly in the data, all points would have been on the 45 degrees line. While not quite equal in all cases, the correlation between the LHS and RHS of equation 3 is striking ( $\rho = 0.87$  for all unordered pairs, and  $\rho = 0.95$  using only Nablus comparisons).

Figure 4: Actual and Imputed Labor Differences - All Unordered Pairs



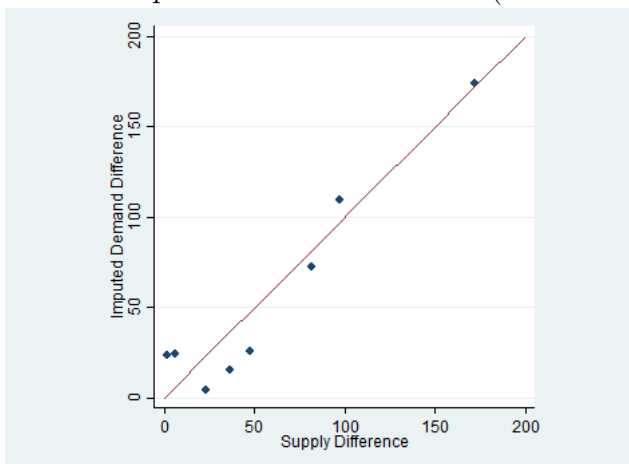
Notes: Each observation is a pair of districts, and the results are in absolute value. Units are 1000 workers. Data on the supply difference is from the Labor Force Survey. Data on imputed demand difference is from establishment surveys and agriculture census.

A more formal way of evaluating how close are the observations to their theoretical prediction (i.e. to the 45 degrees line) is a regression analysis. If the theory described the data perfectly, a regression line of the LHS on the RHS of equation 3, using West Bank data, would result with a coefficient of 1, and an  $R^2$  of 100%. In practice, a no-constant regression of the LHS on the RHS of equation 3 yields a coefficient of 0.96 and an  $R^2$  of 91% for the sample of all unordered pairs, and a coefficient of 0.97 and an  $R^2$  of 95% when Nablus is used as the base for comparisons. Keeping in mind that the data to construct

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sign correct in all cases, not using absolute values increases the correlation between the values on the vertical on horizontal axes. However, it is clear that the only difference that has economic meaning is the absolute value of the difference between districts, not which district is being subtracted from which.

Figure 5: Actual and Imputed Labor Differences (All Districts v. Nablus)



Notes: Each observation is a pair of districts with Nablus being one of the two. All results are in absolute value. Units are 1000 workers. Data on the supply difference is from the Labor Force Survey. Data on imputed demand difference is from establishment surveys and agriculture census.

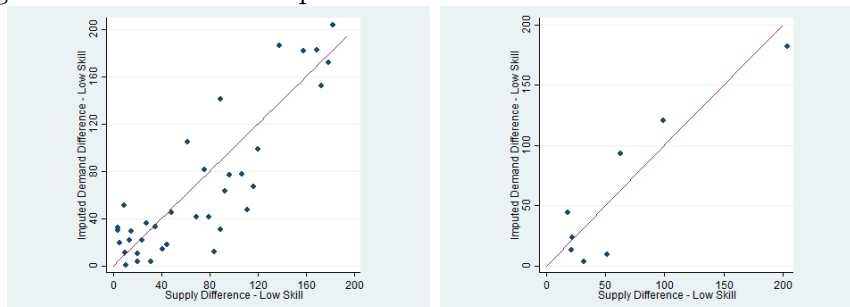
the LHS and the RHS of the tests are taken from different sources, each with its own measurement problems, these results give substantial support to the predictions of the HOV theory for production.

Similar results are obtained for non-college educated workers. Figure 6 reports these results. The correlation between the LHS and RHS of equation 3 when applied to non-college educated workers is  $\rho = 0.86$ , and a no-constant regression line yields a coefficient of 0.96 with  $R^2$  of 88% for all unordered pairs (left panel). When using Nablus as a base for comparison the correlation is  $\rho = 0.90$  and the regression line yields a coefficient of 0.95 and an  $R^2$  of 92%.

However, just how substantial of a support these results give the theory is not clear. As long as marginal productivity of labor is positive, we should expect to find a positive correlation between the supply shock and imputed demand shock. So, for example, there is no meaningful null hypothesis of zero correlation to reject.<sup>12</sup> I address this concern in two ways. First, it is instructive to compare these correlations to the ones found in studies that

<sup>12</sup>And so there is no point in reporting the statistical significance of the correlation, which is a hypothesis test against this null.

Figure 6: Actual and Imputed Labor Differences - Low Skill Workers



Notes: Each observation is a pair of districts, and the results are in absolute value. Units are 1000 workers. Data on the supply difference is from the Labor Force Survey. Data on imputed demand difference is from establishment surveys and agriculture census.

use data on a cross-section of countries. Excluding the U.S., a very large outlier, from the sample, Davis, Weinstein, Bradford, and Shimpo (1997) find a correlation of  $\rho = 0.29$  for non-college graduates, a correlation of  $\rho = 0.271$  for college graduates. For capital, they consider  $\rho = 0.628$  to be a relative success of the model.<sup>13</sup>

Another approach to evaluating the results is to ask how would the results of these tests look if sectoral composition did not play *any* role in the absorption of labor in the West Bank. This is not just a statistical exercise, but also a test of a competing theory: If differential capital flows into districts exactly matched the differential inflows of labor, each district just became a larger replica of itself, with the exact same sectoral composition as before.

To answer this question, I proceed in two steps: First, I create a counter-factual West Bank, in which the relative size of the sectors, as measured by output,<sup>14</sup> remains constant in each district after the shock, but over all output growth, in terms of value, is the same as it was in the real data. That is, in the counter-factual economy, all sectors grow at the same rate, which is the

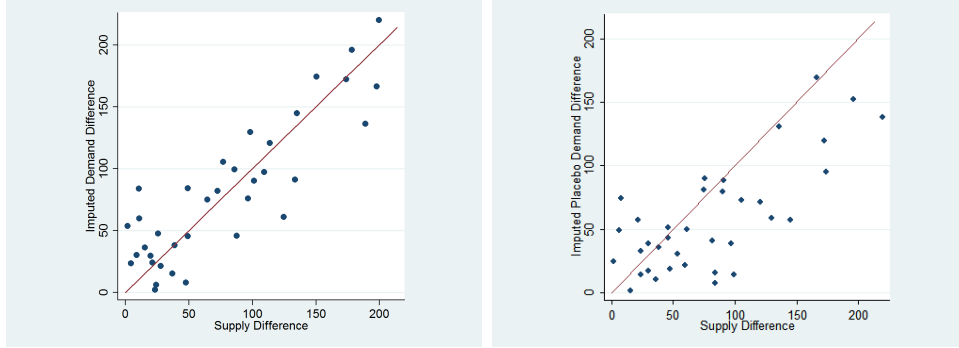
<sup>13</sup>The relative success of the theory's prediction for capital relative to labor is the case in general, as Treffer (2002) explains: "It is by now well known that the Heckscher-Ohlin-Vanek model performs reasonably well for natural resources, less well for capital, and poorly for labor". Thus, the high correlation found here for labor is notable.

<sup>14</sup>Using labor instead of output as a measure for the size of sectors yield very similar results

growth rate of total output in the district in the real data. Having created this counter-factual economy, I then perform on it the same tests as I did with the actual data. The difference between the results of the tests when using the actual data, and the results when using the counter-factual data, is a measure of the importance of sectoral shifts.

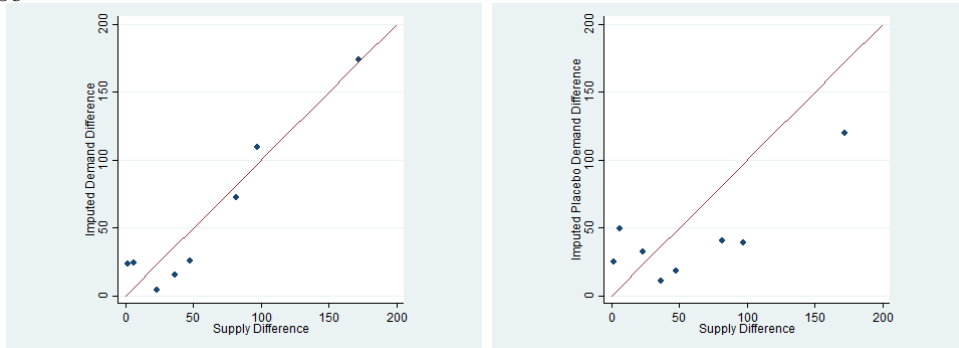
Figures 7 and 8 show these results side by side with the results of the tests on the real data, both for using Nablus as the base of comparison, and for all unordered pairs. The results are exactly as we would expect: most of the points lie well below the 45 degrees line. The way to interpret this is as follows: if the various districts in the West Bank did not change their sectoral composition after the shock to their labor force (i.e if the HOV model is wrong), then a test that assumes that they also kept using the same techniques as before (i.e. a test that assumes the HOV model is right) will fit the data poorly. Moreover, the result is what seem like a substantial under-demand for labor in the districts that received large supply shocks: A regression line of the counter-factual imputed demand change on observed supply shock yields a slope of only 0.60 when all differences are taken against Nablus, and of 0.66 for all unordered pairs. The “under-demand” for labor is as expected. It implies that greater overall growth in total production in districts which received larger labor inflows, by itself, cannot account for the absorption of the labor supply shock, and is not, by itself, the reason for the confirmation of the HOV predictions. It is only when the sectoral composition of production is also taken into account that the tests of the HOV predictions are successful.

Figure 7: Tests of Equation 3 with Counter-Factual and Real data, All Un-ordered Pairs



Notes: The left panel shows the results of testing the prediction of the HOV production model in the real data, and the right panel shows the results of testing the model with a counter-factual data, where the sectoral composition of production is held fixed. All results are in absolute value. Units are 1000 workers.

Figure 8: Tests of Equation 3 with Counter-Factual and Real data, Nablus as Base



Notes: The left panel shows the results of testing the prediction of the HOV production model in the real data, and the right panel shows the results of testing the model with a counter-factual data, where the sectoral composition of production is held fixed. In both Nablus is used as the base against which differences are taken. All results are in absolute value. Units are 1000 workers.

Thus, if differential capital inflows matched the influx of workers, tests of the HOV model would have yielded poor results. The fact that these tests

yield positive results mean that sectoral changes are an important part of the story. The next section deals directly with the possibility that larger labor supply shocks were absorbed, at least partially, through technique changes, and finds evidence against it.

## 4.2 Wages

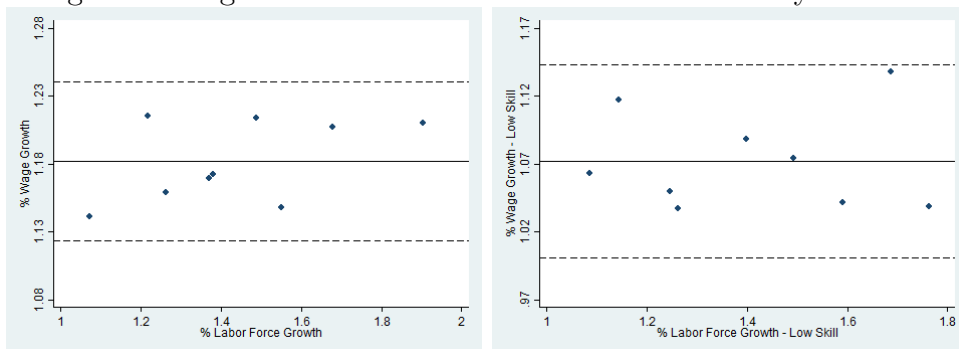
A well known prediction of the HOV model is the so called “Factor Price Equalization” (FPE) theorem. In the HOV model, output prices fully determine the price of factors. Under free and costless trade, all countries face the same output prices, and so, if they share identical technologies, they will have the same factor prices, regardless of relative abundance of factors in each country. This prediction is clearly rejected by international data, as factor prices obviously differ greatly between countries. It is even rejected in the cross section of the West Bank data, with wages differing systematically across districts. However, the natural experiment in the West Bank allows me to test a weaker version of this result, known as Factor Price Insensitivity (FPI), which is difficult to test using cross-section data. According to FPI, factor prices need not be identical everywhere, but they are nonetheless independent of relative factor endowment. In the context of the natural experiment I study, the prediction of the FPI theorem is that the size of the shock to the labor force in a district will not be correlated with wage changes there. An important feature of that prediction is that, unlike the tests described in the previous section, it has an obvious alternative against which it is tested: that districts that received larger labor supply shock, will absorb this excess labor through slower wage growth. Since lower wages are associated with a shift towards more labor intensive techniques, this test is complementary to the tests described in the previous section. There, it was established that sectoral shifts had to have played a role. Here it is established that technique changes did not.

Figure 9 shows the average wage growth in each district between 1999 (before the decline in commuting) and 2007 (the first year of return to full employment), and the percentage change in the size of the labor force in the



district during the same years. The left panel is for aggregate labor, and the right panel is for non-college educated workers only. The correlation between wage growth and the shock to labor supply is essentially zero, and wage increases are not statistically significantly different from each other: A district that became relatively more labor abundant did not experience slower wage growth. This is consistent with the results in the previous section. Since, as was shown there, the relative increase in labor demand that resulted from changes in the sectoral composition of production, matched the increase in labor supply, there was no need for relative wages to fall to absorb excess labor. It is therefore not surprising that wage changes are not correlated with the size of the shock to the labor force in a district, and indeed are generally similar between districts.

Figure 9: Wage Increases and Growth of Labor Force by District



Notes: Data is from the Labor Force Surveys for the years 1999 and 2007. Black lines are the average of the districts average wage increases, and dashed lines are the 1.96 standard deviation band.

### 4.3 Consumption

So far, I have examined the production side of the HOV model of trade. In this section, I supply indirect evidence for the validity of the HOV theorem on the factor content of trade, which states that countries will be net exporters of the services of factors they have in relative abundance. The direct way to test this prediction in the West Bank would be to use data on trade at the district level. Unfortunately, such data does not exist. However, since the factor

content prediction of the theory is derived by simply taking an arithmetic difference between the results of the HOV theory of production, and the HOV assumption about consumption, I supply indirect evidence for its validity by testing the validity of the assumptions about consumption in the model. To be sure, having data on trade at the district level would have contributed to this study a great deal, but while the data I do have are limited, they nonetheless give important support to the HOV theory.

Before turning to the formal tests, it is important to note that while the tests of the production and consumption sides of the model are technically separate, they are conceptually related through general equilibrium effects. Even if the main margin of adjustment of production was sectoral changes, unless the increased production of labor intensive goods was traded away, their prices would have fallen. This, in turn, would have triggered a Stolper-Samuelson effect, and would have led to a decline in wages. Thus, the fact that wages did not fall (or grow slower) in districts that received larger influx of workers, already suggests that increased production of labor intensive goods was traded away, and not consumed locally.

Formally, the HOV theorem is stated as follows. Denoting country  $i$ 's share of consumption of each good out of world consumption of that good by the  $15 \times 1$  vector  $s_i$ , identical homothetic preferences (IHP) imply that all entries in that vector are equal to the share of economy  $i$ 's GDP out of world GDP, and it is therefore possible to treat  $s_i$  as a scalar.<sup>15</sup> Denoting the factor content of trade for country  $i$  by the  $1 \times M$  vector  $F_i$  (with  $M$  being the number of factors), world GDP by  $Y^w$ , the direct plus indirect factor content of goods with the  $15 \times M$  matrix  $A$ ,<sup>16</sup> and keeping all the notation for production from

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<sup>15</sup>This is for the case of balanced economies. If economies are not balanced, their share of world GDP differs from their share of world consumption, which requires adjusting equation 4 to reflect that. It makes no difference for the analysis here. Nor does the fact that the West Bank, or any of its districts were not balanced before or after the shock.

<sup>16</sup>The matrix  $A$  can be stated using the matrix  $B$  and the input output matrix of the economy. However, it makes no difference for the analysis here, and unnecessarily complicates the notation

equation 1, we can state the HOV theorem:

$$BX_i - s_i AY^w = F_i \tag{4}$$

In words: the factor content of production, minus the factor content of consumption, equals the factor content of trade. Defining an economy as abundant in factor  $m$  if its share of world endowment of it is larger than its share of world GDP,  $s_i$ , equation 4 states that an economy will be a net exporter of the services of the factor in which it is abundant. Since trade data is unavailable, the only part of equation 4 that can be tested against data, other than the production side, is the assumption of identical homothetic preferences, which gives rise to the existence of the scalar  $s_i$ , representing both the share of country  $i$  in world GDP and its share of world consumption of each good.

To test whether this assumption is borne out by the data, I use data from the Palestinian Household Expenditure Survey, which details the value of expenditure on a few hundred goods and services, grouped into 26 categories, for a representative sample of households in the West Bank. The assumption of IHP translates into the testable prediction of identical expenditure shares for all categories in all districts. Unfortunately, the data does not report the district of residence of each household, but only divides households to “Northern West Bank”, “Middle West Bank” and “South West Bank”. Moreover, this data too is only available starting at 2009, so only for the time after the decline in commuting to Israel. Nonetheless, it is still informative. There are only two ways in which the data may yield misleading results for our purposes. First, if before 2000, expenditure shares were not consistent with IHP, but after the decline in commuting, changes to production patterns led to a change in consumption patterns that are, coincidentally, consistent with IHP. This seems extremely unlikely. Second, it is possible that differences in expenditure shares between districts average out at this higher level of aggregation. While increasing the level of aggregation may mechanically lead to some averaging out of differences, since there are only 3 or 4 districts in each of North, Middle,

and South West Bank, it seems unlikely that such differences in expenditure shares balanced each other very effectively. It is much more plausible to interpret the data as supporting the assumptions that households in different districts in the West Bank share similar, homothetic, preferences.

Table IV reports average consumption shares on each of 24 groups of goods, that together cover essentially all of household consumption, in each of the three regions of the West Bank.<sup>17</sup> The resemblance in expenditure shares is remarkable. The correlation in the size of expenditure shares between districts ranges between 0.93 (“North” and “Middle”) and 0.95 (“South” and “Middle”). These high correlations are not the result of some categories being inherently much larger than others: The Spearman rank correlations are also very high, ranging from 0.936 (“North” and “Middle”) to 0.944 (“North” and “South”). This is especially notable, since the value of total expenditure (and so, presumably, income level) differs by 10%-20%. Considering the inherent noise in consumption reporting, these results are consistent with the IHP assumption, at least at this level of aggregation.

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<sup>17</sup>I exclude the value of home produced good, which are likely to be poorly measured, and impossible to price, and the value of consumption of alcoholic beverages, since in a predominantly Muslim society there may be severe under-reporting on actual consumption of alcohol.

Table IV: Consumption Shares in the West Bank

	Northern West Bank	Middle West Bank	Southern West Bank
Average Total Expenditure (NIS)	4,647	5,032	4,201
Bread and cereals	6.6%	5.9%	6.5%
Meat and poultry	8.4%	11.0%	12.8%
Fish and sea products	0.6%	0.7%	0.8%
Dairy products and eggs	3.2%	3.9%	3.5%
Oils and fats	1.6%	1.4%	1.4%
Fruits and nuts	3.2%	2.9%	3.1%
Vegetables, legumes and tubers	4.3%	4.4%	5.5%
Sugar and confectionery	2.0%	2.4%	1.7%
Non alcoholic beverages	1.9%	2.4%	1.9%
Salt, spices and other food	2.3%	2.3%	1.5%
Take away food and meals in restaurant	4.2%	3.0%	2.0%
Clothing and footwear	7.6%	7.5%	7.3%
Housing related	8.0%	12.7%	9.5%
Furniture and utensils	5.5%	5.0%	3.2%
Household operations	1.6%	1.6%	1.3%
Medical care	5.2%	3.9%	4.2%
Transportation	13.5%	17.7%	13.7%
Education	3.3%	3.9%	3.3%
Recreation	1.5%	2.5%	1.1%
Personal care	2.9%	3.6%	2.5%
Tobacco	5.3%	7.0%	6.4%
Other non-food consumption expenditure	5.6%	4.0%	3.4%
Imputed rent	10.1%	17.5%	11.1%
Communications	4.0%	5.7%	3.0%
N	1,189	988	725

It is important to understand these results in the context of the results from the previous section. It is because the different parts of the West Bank shared identical homothetic preferences, that increases in the production of labor intensive goods were traded away, and did not result in a relative fall in the prices of labor intensive goods in districts that received larger labor influxes, which in turn would have led to a relative decline in wages there.

## 5 Conclusions

The exogenous fall in commuting options from the West Bank to Israel led to a large shock to the size of the labor force in the West Bank, an effect that varied between different districts there. Allowing for district specific, and time specific characteristics, I find that the changes in production patterns are consistent with the predictions of the Heckscher-Ohlin-Vanek model of trade. Moreover, these changes allowed for an absorption of the returning commuters, without relative wage changes, as predicted by the FPI theorem. While no direct data on trade exist at the district level, data on consumption is consistent with the assumption of identical homothetic preferences in the West Bank, thus giving indirect support for the HOV theorem on the factor content of trade. Yet, all three of these predictions failed in cross sectional tests conducted in previous studies. What are we then to make of these new findings?

It should come as no surprise that the HOV theory is not a sufficient theory to explain the actual trade patterns we observe in the real world - Germany and China are different in many ways other than the relative supply of different kinds of labor and capital, and some of these differences affect trade patterns in ways that the HOV theory fails to capture. However, that does not render the theory useless. While the original insights of Eli Heckscher and Bertil Ohlin are not sufficient to explain world trade patterns, the experience of the West Bank suggests that they nonetheless describe a real and important aspect of international trade, and do very well in explaining how an open economy adjusts to shocks to its factor markets by modifying the composition of production, and trading away the excess production. Whatever other forces shape trade patterns, relative factor abundance do play a role.

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## A Data Appendix

Data on wages, employment and commuting is from the Palestinian Labor Force Survey, conducted by the Palestinian Central Bureau of Statistics. The survey is conducted at a quarterly frequency, and is explicitly designed to be geographically representative, based on the population census. In the year 1999, a total of 53,489 persons over the age of 15 were sampled in the West Bank, and in the year 2007 the number was 52,568. Data on agricultural output is taken from the agricultural censuses of the Palestinian authority for 1999 and 2007. Data on output of the rest of the sectors comes from the firm censuses of 1997 and 2007, and the surveys of manufacturing, services, construction, transportation, and retail trade. All surveys are explicitly designed to be geographically representative. To calculate the unit labor requirements in each industry I divide total gross output in the industry in a year by the number of workers in this industry in this year. Data on consumption is from the Household Expenditure Survey of 2009, conducted by the Palestinian Central Bureau of Statistics. It is explicitly designed to be geographically representative. In 2009, it sampled 2,909 households in the West Bank, detailing expenditure level of 659 items, classified into 26 main groups.