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The Long-Run Effects of Trade on Income and Income Growth

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Abstract

This paper examines the dynamic relationship between trade and income. While most economists agree that increased trade leads to an increase in average income, economic theory is ambiguous about the possible effects on the long-run growth rate of the economy. Using a dynamic panel data model, the hypotheses of no long-run effects of trade on income and on income growth are tested explicitly. The possibility of endogeneity is addressed by constructing an instrument for trade by extending Frankel and Romer's (1999) cross-sectional approach to the case of a panel data model. The empirical results indicate that trade has a large and significant effect on the level of income, but the effect on income growth is small and non-robust to model specification.

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Contents

I. INTRODUCTION

Most economists agree that increased trade should lead to a one-time increase in GDP as country resources are allocated more efficiently. They do not seem to agree on whether trade can influence the long-run growth rate of the economy. Most traditional models of growth have no such role for trade, as the long-run growth rate is determined by exogenous technological progress. The "new" dynamic growth theories, however, offer much more scope for trade to affect economic growth, since increased openness provides more access to imported inputs (which can embody new technology), increases effective market size (which increases the return to innovation), and can direct domestic resources toward research-intensive production.

The net benefits of increased trade on economic growth are not necessarily positive, as demonstrated by Grossman and Helpman (1991) and others. While there might be an overall efficiency gain that raises the level of income, increased trade openness can also change the relative price of tradables and divert resources away from sectors where increasing returns exist. Whether increased competition pushes an economy's resources toward or away from activities that generate increased long-run growth depends on the country's comparative advantage at the time of the liberalization. Put somewhat differently, if an economy is lagging in technological development, temporary import protection can allow it to catch up to more advanced economies rather than being forced to specialize in the production of traditional goods and experience a reduction in long-run growth, along with the higher level of income.

There is a vast amount of empirical work that addresses the openness-income relationship - see the literature reviews by Edwards (1993) and Harrison (1996) and the recent critique by Rodriguez and Rodrik (1999). While many studies have found a positive relationship between trade and income, this relationship is generally not robust. Economists have pointed to a number of methodological and econometric problems that could account for the lack of robustness. First, research must confront the fact that there are no direct measures of trade openness. Several approaches have been taken to circumvent this problem, including the use of trade shares (exports plus imports divided by GDP)[2], measures of price distortions that are created by trade protection[3], and dummy variables constructed using quantitative and qualitative judgments[4]. Harrison found that these openness measures are generally correlated with income but the relationship is not robust to changes in the econometric specification.

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[2] See, for example, Balassa (1985), Edwards (1992), and Chong and Zanforlin (2000).

[3] Barro (1991), Bhalla and Lau (1992), and Dollar (1992) offer some suggestions for measuring these distortions.

[4] This approach was taken by Ben-David (1993), Sachs and Warner (1995), and Slaughter (1998).

Second, there is the distinct possibility of reverse causation – income affecting trade openness – which can bias the estimated effects of trade on income. Frankel and Romer (1999) and Irwin and Terviö (2002) used geography variables – which are known to be correlated with trade flows but are unlikely to affect income other than through the trade channel – as instrumental variables for estimating the trade-output relationship.

Third, Rodrik (1999) has recently pointed out that the benefits from openness are "potential benefits, to be realized only when the complementary policies and institutions are in place domestically". This idea emphasized that benefits cannot occur unless certain infrastructure – rule of law, good macroeconomic policies, adequate financial markets, functioning government institutions – are not available. It also suggests a contingent or nonlinear relationship between income and trade, which could help explain the non-robustness seen in linear models.

Finally, Fischer (1993) argued that most econometric studies use ad hoc, reduced-form specifications, making it impossible to understand the channels of causation of trade on income. He advocated a production function approach and found that trade liberalization's positive effects are largely associated with productivity gains.[5]

There is another econometric problem that has not been pointed out in the literature. Much of this literature consists of cross-sectional regression analysis, where income or income growth for a number of countries is regressed on some measure of trade. As we will discuss in the next section, cross-sectional regressions cannot disentangle the effects of trade on the level of income from the effects on the growth rate of income. Thus, for the most part, the literature is silent on whether the estimated benefits to income of increased trade are due to a higher level income or to a higher growth rate of income.

The level versus growth rate debate can only be settled by using a panel data set - that is, by exploiting both the cross-sectional and the time-series properties of the data. In fact, the time-series aspects of the data are critical for addressing this question, since the answer is intimately related to the order of integration of GDP and trade. Let y denote the log of per capita GDP, and let Δy denote the first difference of y. First, changes in trade openness can have permanent effects on y or Δy only if there are permanent changes in trade openness. Thus, a necessary condition is that trade openness must be an I(1) variable. Second, changes in trade openness can have permanent effects on y only if y is integrated of order 1 or higher. Similarly, trade changes can have permanent effects on Δy only if Δy is integrated of order I(1) or higher. In other words, for trade (TRD) to have permanent effects on output, it is necessary for both y and TRD to be at least I(1); and, for trade to have permanent effects on output growth, it is necessary for both Δy and TRD to be at least I(1).

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[5] Similarly, Choudhri and Hakura (2000) found that these productivity gains are larger for medium-to-high growth sectors compared to low-growth sectors, lending some credence to the existence of increasing returns in some sectors.

These necessary conditions are testable hypotheses and are addressed in the next section of the paper. As it turns out, the null hypothesis that the trade is an I(1) variable can be rejected for only a handful of the 125 countries examined. Similarly, the null hypothesis that log GDP per capita is an I(1) variable cannot be rejected for the vast majority of countries in my sample. Thus, the necessary conditions are met for trade to have a long-run effect on the level of income. On the other hand, the null hypothesis that income growth is an I(1) variable can be rejected in 90 cases. Thus, the necessary conditions for trade to have a long-run effect on GDP growth is met for only 35 of 125 countries.

We then proceed to test whether trade has long-run effects on income or income growth. These tests are done in the context of several estimated panel data models, using annual data from 1960-92 for 125 countries. There are a few studies that have moved in this direction, but there are some potential drawbacks to their approaches. First, Sachs and Warner (1995) examined the growth effects of trade liberalization. Their approach was to calculate average growth rates for "liberalizers" in the years following the liberalization. While this is much superior to a simple cross-section, they did not control for other variables that might also affect income that are correlated with trade liberalization. In addition, they do not address the possibility that trade is endogenous with respect to income and income growth. Second, while Chong and Zanforlin (2000) use a panel data model, their time-series observations consist of 5-year averages. Their motivation is to remove the business-cycle variations in trade and income. Still, 5-year averages are somewhat arbitrary for a set of developed and developing countries and important information about the trade-income relationship might be lost with this approach. In addition, while they use an instrumental variable approach, their list of instrumental variables does not include geography variables. Finally, Choudhri and Hakura (2000) examine the effects of trade on productivity growth. While this is likely an important channel of causality, trade might also have important influences on factor accumulation, including the accumulation of human capital. Therefore, we maintain income and income growth as the dependent variable.

This paper address the possibility that trade is endogenous, just as in a cross-sectional regression. In this paper, we extend Frankel and Romer's cross-sectional approach to the panel data case and construct a instrumental variable based on geography variables, which are highly correlated with trade but are unlikely to affect income other than through trade.

The parameter estimates from the panel data models are consistent with those obtained by Frankel and Romer and by Irwin and Terviö. However, importantly, the panel data models are able to distinguish between the effects of trade on income and the effects of trade on income growth. The results indicate that a one percentage point change in trade is associated with a one percentage point change in average income. This estimate is both significant from zero and robust to changes in the econometric specification. On the other hand, the estimated effect of trade on income growth is quite small, and the estimated relationship is not robust to the econometric specification.

The remainder of the paper is organized as follows. The econometric strategy is described in Section II. The construction of the instrument for trade shares is discussed in

Section III. Empirical results and robustness checks are presented in Section IV. Section V presents concluding remarks.

II. The Econometric Strategy

As discussed in the previous section, the objective of this paper is to measure the long-run effects of changes in trade on both the level and the growth rate of average income. While many studies have found positive relationships between trade and income and between trade and income growth, these relationships are not generally robust. The raw correlations shown in Figures 1 and 2 indicate the difficulty in identifying the partial correlation between trade and income or between trade and income growth.[6]

In addition, the vast majority of these studies are cross-sectional in nature, regressing either income for a given year or income growth over a range of years on some measure of trade.[7] Unfortunately, a cross-sectional study cannot be used to distinguish whether the effect of increased trade on income is because of a change in the level of income or because of a change in the growth rate of income.

This point is illustrated by Figure 3. Each panel illustrates the effects of increased trade (liberalization) on average income relative to no changes in trade (no liberalization). In the absence of a change in trade, average income will grow to y_2 at time t_2. Now, consider the effects of a trade liberalization at time t_1. The upper panel illustrates the case where there is an immediate, one-time shift in the level of income due to liberalization, but the growth rate of average income is unaffected. As a result, average income after liberalization grows to $y_2^{'}$ at time t_2. The lower panel shows the case where liberalization has a positive effect on the growth rate of income, although there is no change to the level of income. As in the previous case, average income after liberalization grows to $y_2^{'}$ at time t_2.

Now, suppose that we collect average income and the trade shares for a number of countries – some with trade liberalization and others without – for the time period t_2. (This is the approach taken by Frankel and Romer, Irwin and Terviö, and a number of other studies.) If we use this cross-sectional data set to regress average income on trade shares, we will find that, indeed, the estimated effect of the trade liberalization is $y_2 - y_2^{'}$. Suppose, instead, that we collect average income growth and the average trade share for a number of countries for the period from t_0 to t_2. (This is the approach taken by Barro, as well as a number of other studies.) In this case, again, we will find that, indeed, the estimated effect of the trade liberalization is also $y_2 - y_2^{'}$. Thus, in cross-sectional regressions, we cannot infer whether the effects of trade changes are to the level of income or to the growth rate of

[6] The data used in this paper are described below.

[7] Two important exceptions are Chong and Zanforlin (2000) and Choudhri and Hakura (2000), which were discussed earlier.

average income, regardless of whether the regressions are estimated in levels or in growth rates.

The level and growth rate effects can be disentangled, however, by using a panel data model. Indeed, long-run restrictions on the model coefficients – that the long-run effects of changes in trade shares are equal to zero – can then be tested explicitly. A second important advantage of the panel data model is that fixed country and time effects can be used in a panel data context to proxy for unobserved variables that are correlated with both income and trade. If these effects are important but not included in the statistical model, the estimates of the effects of trade on income will be biased.

The remainder of this section presents the dynamic panel data model, discusses the appropriate restrictions for testing the long-run effects of trade changes, describes the data sources, and summarizes the time series properties of the model variables.

A. The Econometric Model

Average income for a country is determined by those factors that influence trade within its borders (within-country trade), its economic interactions with other countries (international trade), and all other factors. We can write this relationship as follows:

$$y_{it} = \mu_i + \mu_t + \beta_y TRD_{it} + \lambda Z_{it} + \varepsilon_{it} \tag{1}$$

where y_{it} denotes the log of real GDP per capita for country i during year t; TRD_{it} represents the country's trade share (exports plus imports divided by total GDP); Z_{it} is a vector of additional factors that influence within-country trade (and potentially international trade); μ_i and μ_t are fixed country and time effects; and ε_{it} is an error term, distributed by a stationary error process with mean 0 and variance σ_{it}.

In addition, we can consider the possible long-run effects of trade on income growth as follows:

$$\Delta y_{it} = \mu_i + \mu_t + \beta_{\Delta y} TRD_{it} + \lambda Z_{it} + \varepsilon_{it} \tag{2}$$

where Δy_{it} denotes the first difference of y_{it}; that is, the growth rate of real GDP per capita.

As discussed earlier, there is the distinct possibility of reverse causation, where average income influences the degree of international trade. Thus, equations (1) and (2) must be estimated using instrumental variable (IV) techniques. In the next section, we demonstrate how Frankel and Romer's cross-sectional IV approach can be extended to the panel data situation.

Once the panel data models in (1) and (2) are estimated, the estimated coefficients can be used to measure the long-effects of changes in trade (TRD_{it}) on the level of average income (y_{it}) or on the growth rate of average income. How can we interpret β_y and $\beta_{\Delta y}$? As it turns out, the magnitude of the estimated long-run effects of changes in trade on income or on income growth – whether undefined, zero, finite, or infinite – depend intimately on the order of integration of the trade shares and average income variables.

Following Fisher and Seator (1993), we can define the long-run derivative of income with respect to trade ($LRD_{y, TRD}$) and the long-run derivative of income growth with respect to trade ($LRD_{\Delta y, TRD}$). In the context of this paper, there are four important cases, which are summarized in Table 1. First, if the trade share for a country (TRD_{it}) is a stationary variable – that is, TRD_{it} is an I(0) variable – then there are no permanent changes in trade. In this case, both long-run derivatives are undefined.

Second, consider the case where TRD_{it} is an I(1) variable, but income (y_{it}) is an I(0) variable. In this case, since y_{it} is a stationary variable, it cannot be affected permanently. Hence, $LRD_{y, TRD}$ is defined as 0, and, similarly, $LRD_{\Delta y, TRD}$ is defined as 0.

Third, when TRD_{it} and y_{it} are both I(1) variables, trade shares can affect the long-run level of income but cannot affect the long-run growth rate of the economy. Thus, $LRD_{y, TRD} = \beta_y$ – the estimated coefficient in equation (1) – but $LRD_{\Delta y, TRD} = 0$.

The final case is when TRD_{it} and Δy_{it} are both I(1) variables. That is, trade shares can affect the long-run level of growth rate of the economy. In this case, $LRD_{\Delta y, TRD} = \beta_{\Delta y}$. Importantly, if TRD_{it} and Δy_{it} are I(1), and trade shares do have a long-run impact on income growth ($\beta_{\Delta y}$ is estimated to be different from zero), the estimated coefficient β_y has no interpretation. In this case, trade shares will have an infinite effect on the level of income – that is, $LRD_{y, TRD} = \infty$.

B. Data Sources

The panel data sets used in the paper are for 125 countries over 33 years (1960-92). The data sources are generally the same as in Frankel and Romer. The bilateral trade data are from the International Monetary Fund's Direction of Trade Statistics. As pointed out in the empirical trade literature, these data are not completely reliable. The bilateral trade data have many missing values, trade values recorded as zero are probably very small rather than actually zero, and one country's exports are sometimes inconsistent with its trading partner's imports. Since the bilateral trade regressions are specified in logs, we treat the zero values as missing values.

Nominal GDP, real GDP per capita, and total population were obtained from the Penn-World Tables (Mark 5.6), which are distributed by the National Bureau of Economic Research. Distance was calculated as the great-circle distance between country capitals. The geography variables – area, the landlocked dummy, the common border dummy, latitude, and longitude were constructed from information in Rand McNally (1993). The common language dummy was constructed from the list of official languages cited in the CIA's *World Factbook* (2002).

C. Augmented Dickey-Fuller Test Results

As discussed above, the order of integration of the trade and income variables give us important clues as to the possible long-run effects of trade on income and income growth. Consequently, we ran augmented Dickey-Fuller tests on several time-series variables for each of 125 countries, using three possible specifications:

$$\Delta x_t = \mu + \rho x_{t-1} + \psi(L)\,\Delta x_{t-1} + u_t$$

$$\Delta x_t = \mu + \rho x_{t-1} + \theta t + \psi(L)\,\Delta x_{t-1} + u_t$$

$$\Delta^2 x_t = \mu + \rho\,\Delta x_{t-1} + \psi(L)\,\Delta^2 x_{t-1} + u_t$$

where x_t is either a) the trade share, b) the trade share instrument (to be discussed in more detail in the next section), or c) log real GDP per capita. Note that the null hypothesis in the first two specification is that x_t is an I(1) variable and that the null hypothesis in the third specification is that x_t is an I(2) variable. In addition, these specifications allow for a reasonable range of possible alternative hypotheses: x_t is stationary, x_t is stationary around a time trend, and x_t is an I(1) variable, respectively.

The results of these tests are summarized in Table 2. Each entry in the table indicates the number of rejections (out of a possible 125) at the 5% critical value for one of three null hypotheses: a) I(1) against I(0) without a time trend, b) I(1) against I(0) with a time trend, and, c) I(2) against I(1) without a time trend.

The results for the trade share and the trade share instruments – rows 1 and 2 – are fairly conclusive. There are very few rejections of the I(1) hypotheses, indicating that the trade share variables are at least I(1) variables for the vast majority of countries. In addition, the I(2) hypotheses are rejected for about 95 percent of the cases. A reasonable conclusion is that the trade shares are I(1) variables. This leaves open the possibility that trade shares can have long-run effects on either income or income growth for most countries.

The results are somewhat less clear for the average income variables. The null hypotheses of I(1) are rarely rejected, indicating that GDP per capita is at least an I(1) variable for most countries. However, the null hypothesis of I(2) is rejected in only about 75 percent of the cases, suggesting that several countries have non-stationary growth rates. The 35 countries or areas for which we cannot reject that income is I(2) are listed in Table 3. Interestingly, the list contains several developing countries with significant periods of trade liberalization – for example, Singapore and Mauritius – plus several North American and European developed countries that have also experienced substantial reductions in trade barriers.

In summary, there is fairly convincing evidence that trade shares are I(1) variables. Thus, there are indeed permanent changes to trade for the vast majority of the sample countries. In addition, average income appears to be at least I(1), allowing for the possibility that trade has a long-run effect on the level of average income. Finally, we cannot completely reject the hypothesis that income growth is an I(1) variable, as well. This allows for the possibility that permanent changes to trade have an influence on the long-run growth rates of some countries. We will investigate this possibility in Section IV of the paper.

III. Constructing the Trade Instrument

As many economists have pointed out, the models in (1) and (2) present an important econometric difficulty. Trade shares are likely to be endogenous, since countries whose incomes are high (for reasons other than trade) are likely to have more international trade. This difficulty can be addressed with instrumental variable (IV) estimation. Recently, Frankel and Romer (1999) argued that geography variables, describing a country's size and its proximity to other countries, are valid instruments for trade shares, since geography variables are known to be powerful predictors of trade patterns but are unlikely to affect average income other than through their influence on international trade. Frankel and Romer's approach is cross-sectional in nature.[8] In this section, we describe how to construct a trade instrument for use in the context of a panel data model.

As in Frankel and Romer, the trade share instrument is constructed from bilateral trade data. The bilateral trade equation can be written as follows:

$$\log\left(\frac{\tau_{ijt}}{GDP_{it} GDP_{jt}} \right) = \mu_t + \gamma W_{ijt} + v_{ijt} \qquad (3)$$

where τ_{ijt} denotes total trade between countries i and j during year t; GDP_{it} and GDP_{jt} are total GDP for country i and j, respectively, during period t; μ_t are time effects; W_{ijt} is a vector of bilateral trade determinants; and v_{ijt} is distributed by a stationary error process.

Once equation (3) has been estimated, the trade share instrument ($\widehat{TRD}_{it}$) can be calculated as:

$$\widehat{TRD}_{it} = \Sigma_{j \neq i} \exp(\mu_t + \gamma W_{ijt}) \ GDP_{jt} .$$

For this to be a valid instrument for trade shares in equations (1) and (2), W_{ijt} cannot include average income (y_{it}) or average income growth (Δy_{it}). In addition, if W_{ijt} contains a factor that influences average income other than through its effects on international trade, this factor must also be included in the list of control variables (Z_{it}) in (1) and (2).

[8] Frankel and Romer use their trade share instrument to examine the effects of trade on income in 1985. Irwin and Terviö have also used this cross-sectional approach to analyze other periods during the 20th century.

Following the literature on the gravity-equation model of international trade, there are several possible determinants of bilateral trade flows. First, country incomes are probably the most important determinant of the demand for imported goods and services. Indeed, GDP is likely to be extremely influential during the time period under study (1960-92), because world income was recovering from World War II and because many developing countries were growing rapidly during this period due to rapid accumulations of improved technologies, human capital, and other factors of production.

Second, as emphasized by the literature on monopolistic competition models of international trade – see Helpman and Krugman (1985) – income disparity is also likely to be an important determinant of trade. According to those models, similar incomes lead to more intra-industry trade. Over the 1960-92 period, there was significant economic convergence among many developed and developing economies, which may have boosted overall trade for these countries. Following Helpman (1987), we define income disparity as:

$$YDISP_{ijt} \quad = \quad 1 - s_{it}^2 - s_{jt}^2$$

where $YDISP_{ijt}$ denotes income disparity between countries i and j, and s_{it} and s_{jt} are income shares, for i and j, respectively, relative to total GDP for the two countries.

Third, as discussed by Frankel and Romer, geography is a powerful determinant of bilateral trade. Following Frankel and Romer and others, we consider a number of geographic variables in the bilateral trade equation, including population, area, dummy variables indicating whether countries are landlocked, dummy variables indicating whether country pairs share a common border, and dummy variables indicating whether countries share a common language.

Fourth, reductions in transportation and communication costs have also likely boosted international trade. Reductions in transportation costs have both positive direct effects (by reducing the price of imported goods and services) and positive indirect effects (by making it less expensive to acquire information about foreign goods). It is less clear what the net effect of lower communication cost will be on trade. On the one hand, such cost declines should also lower information costs and have a positive effect on trade. However, lower communication costs can also make it easier to manage foreign direct investments, which could either raise or lower trade, depending on whether foreign direct investment is a complement or a substitute for foreign trade.

A final important determinant is trade policy. Again, this factor is likely to have been substantial during the sample period, because much of the world was devoted to lowering trade barriers that were erected during the inter-war period. The reduction of trade barriers was accomplished through a number of channels, including multilateral trade agreements (such as GATT and WTO), through regional trade agreements (for example, EEC, EFTA, NAFTA, and MERCOSUR), through bilateral trade agreements (such as the U.S./Canada Agreement), and through unilateral agreements (generally motivated by contingent offers of foreign aid).

It is well known in the trade literature that transport costs, communication costs, and tariff and non-tariff barriers are poorly measured and are not available for a wide number of countries and for long time spans. Therefore, we do not include them directly in the construction of the trade share instrument. This is not a serious econometric issue, unless these factors are also affect intra-national trade. Indeed, it is likely that intranational and international measures of transportation and communication costs are highly correlated. We attempt to capture these factors with time and country dummies.

We consider several specifications of equation (3). The "basic" specification is the panel-data version of the specification used by Frankel and Romer and by Irwin and Terviö:

$$
\begin{aligned}
\log\left(\frac{\tau_{ijt}}{GDP_{it}GDP_{jt}}\right) = \; & \mu_t + \gamma_{1t} \log DIST_{ij} \\
& + \gamma_{2t} \log POP_{it} + \gamma_{3t} \log POP_{jt} \\
& + \gamma_{4t} \log AREA_i + \gamma_{5t} \log AREA_j \\
& + \gamma_{6t} (L_i + L_j) + \gamma_{7t} BORDER_{ij} \\
& + \gamma_{8t} \log DIST_{ij} \; BORDER_{ij} \\
& + \gamma_{9t} \log POP_{it} * BORDER_{ij} + \gamma_{10t} \log POP_{jt} * BORDER_{ij} \\
& + \gamma_{11t} \log AREA_i * BORDER_{ij} + \gamma_{12t} \log AREA_j * BORDER_{ij} \\
& + \gamma_{12t} (L_i + L_j) * BORDER_{ij} + v_{ijt}
\end{aligned}
$$

where $DIST_{ij}$ denotes the distance between the capitals of country i and j; POP_{it} and POP_{jt} denote the populations of i and j, respectively, during period t; $AREA_i$ and $AREA_j$ represent the geographical size of country i and j, respectively; L_i and L_j are dummy variables, where a value of 1 indicates that the country is landlocked; and $BORDER_{ij}$ is a dummy variable, where a value of 1 indicates that countries i and j share a common border.

Note that all coefficients are allowed to be time-varying. In this way, we can capture the time-varying influences of these variables. For example, time-varying coefficients could capture the effects of changes in transportation and communications costs or the effects of newly-introduced regional trade agreements.

Table 4 shows the results of several Wald tests. As previously mentioned, we will consider four specifications of equation (3) – the basic specification and three alternatives. For each specification, Table 4 reports the p-values for two sets of Wald tests. The first set are tests of whether a group of coefficients are "equal to each other". This is simply a tests of whether the time-varying coefficients are, in fact, time-invariant. The second set are Wald tests of whether a group of variables are "equal to zero".

The number of estimated coefficients in the basic specification is quite large (462). Therefore, the coefficients (excluding the interactive terms) are plotted in Figures 4 through 9. The time dummies – Figure 4 – are statistically different from zero and are fairly constant over time, indicating that there have been no broad trends in trade shares during the sample period. The effects of the geography variables are consistent with previous cross-sectional studies. Distance, own population, trading partner population, own area, trading partner area, and the landlocked dummy have negative and statistically significant effects on trade. In addition, these variables are generally time-varying. With the exception of population – which has had a declining effect on trade – these variables have become more important over the sample in reducing trade shares. With respect to distance and landlocked countries, this could reflect more trade with closer and more accessible trading partners because of the proliferation of free trade agreements (generally with neighboring countries).[9] Taken together, the population and area variables suggest that dense populated countries are trading more in recent years compared to the 1960s. Given the results for distance and for landlocked countries, it is somewhat puzzling that the common border dummy is not significantly different from zero. Finally, while many of the interactive terms are significantly different from zero, they are not generally time-varying.

The predicted trade shares are compared to actual trade shares in Figure 10. As in Frankel and Romer, the constructed trade instrument is only moderately correlated with actual trade shares – 0.46 in our case, compared to a correlation of 0.38 in Frankel and Romer.

In addition to the basic specification, we consider three alternative specifications, in order to test the robustness of the GDP regressions in the next section. First, we add income disparity to the list of regressors. As shown in Table 4, income differences are statistically important, although their interaction with the common border dummy are not. These additional regressors also lower the variance of the regression residuals.

Secondly, we also add eight common language dummies (for English, Spanish, German, French, Chinese, Arabic, Dutch, and Portuguese) to the list of regressors. These variables are also statistically different from zero, and substantially reduce the variance of the regression residuals. Finally, we restrict the regression to only OECD countries. This seems reasonable, since the bilateral trade data for these countries is likely to be more reliable.

IV. THE ESTIMATED EFFECTS OF TRADE ON INCOME

In this section of the paper, we turn to estimating the long-run effects of trade on income and income growth. In order to test the robustness of our results, we estimate these effects using a number of different regression specifications, two estimation techniques (ordinary least squares and instrumental variables), and several different measures of the instrumental variable.

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[9] This result is not consistent with the prevailing view that transport costs have fallen. On the other hand, Hummels (1999) has recently argued that ocean freight rates have increased, while air freight rates have fallen in the post-WWII era.

Recall from Section II that we are interested in estimating the following relationships:

$$y_{it} = \mu_t + \mu_i + \beta_y TRD_{it} + \lambda Z_{it} + \varepsilon_{it} \qquad (1)$$

$$\Delta y_{it} = \mu_i + \mu_t + \beta_{\Delta y} TRD_{it} + \lambda Z_{it} + \varepsilon_{it} \qquad (2)$$

Tables 5 and 6 present parameter estimates for the above models, respectively. The upper panel of each table shows the results when using ordinary least squares (OLS), while the lower panels show the instrumental variable (IV) results. In addition to trade share and population as explanatory variables, we consider three lists of additional regressors: i) area, ii) country dummies, and iii) country and time dummies.

The results in Tables 5 and 6 can be summarized as follows. First, the country and time dummies provide important explanatory power, especially for explaining income levels. Second, generally the IV coefficients for trade shares are estimated with less precision than the OLS estimates. Finally, when considering estimates using IV and including country and time dummies, the estimated effects of trade on income and income growth are quite small and insignificant from zero.

The panel-data regressions in (1) and (2) above are analogous to time-series models for testing for evidence of cointegration. Indeed, in our case, we are interested in possible cointegrating relationships: We are interested in whether permanent changes to trade have permanent effects on income or on income growth. We know from the time-series literature that misspecifications of (1) and (2) – for example, the errors (ε_{it}) are autocorrelated – can lead to inefficient estimation. A number of efficient methods have been developed, including the single-equation error correction models discussed in Engle and Granger (1987).

Accordingly, we extend our analysis to the following models:

$$\Delta y_{it} = \mu_t + \mu_i + \rho(y_{it-1} - \beta_y TRD_{it-1}) + \delta_y \Delta TRD_{it-1} + \lambda Z_{it} + \varepsilon_{it} \qquad (4)$$

$$\Delta^2 y_{it} = \mu_t + \mu_i + \rho(\Delta y_{it-1} - \beta_{\Delta y} TRD_{it-1}) + \delta_{\Delta y} \Delta TRD_{it-1} + \lambda Z_{it} + \varepsilon_{it} \qquad (5)$$

where β_y and $\beta_{\Delta y}$ continue to measure the long-run effects of trade on income and income growth, respectively; δ_y and $\delta_{\Delta y}$ capture the short-run response of income and income growth to changes in trade shares, respectively; and ρ measures the rate at which income and income growth adjust to their long-run levels. Note that the key to identifying these models as structural models is that δ_y and $\delta_{\Delta y}$ must be estimated as non-zero. Otherwise, these relationships are reduced-form rather than structural relationships, and, in that case, we cannot make any causal assessments of trade effects.

The estimation results for equations (4) and (5) are shown in Tables 7 and 8. The results can be summarized as follows. First, country dummies appear to be quite important in reducing the variance of regression errors, while time dummies are only modestly important. This later result is not too surprising, given that the dependent variables are now measured in growth rates and changes in growth rates. Nevertheless, these dummies could be capturing global growth or trade cycles over the sample period.

Second, the short-run effects of trade on income and income growth are estimated to be positive, as expected, although they are often only marginally significant from zero. In particular, for the case where the short-run effect is estimated with IV and both country and time dummies were included, the t-statistic is only 1.2. This is somewhat disappointing, since non-zero estimates for these parameters are necessary for structural identification. Nevertheless, on a positive note, in most other specifications the coefficients are estimated more precisely, and in all cases the estimated coefficients are positive.

Third, the coefficients for estimating the long-run effects are estimated quite precisely. The estimated long-run elasticities that are implied by these estimated coefficients are shown in Table 9. Estimates of the long-run effect of trade on GDP per capita are shown in the first three rows of the table. The estimates are all positive and significantly different from zero. The estimates show that a one percentage point change in the trade share leads to about a one percentage point change in average income. Interestingly, this estimate is very similar to estimates obtained using cross-sectional regression methods. With those methods, however, we can attribute the estimated effect to changes in either income or income growth

The estimates of trade effects on income growth are shown in the last three rows of Table 9. Unfortunately, the estimates are not robust to different regression specifications. Moreover, even if we focus on the IV estimate with country and time dummies – which is positive and significant from zero – the estimated long-run effect on income growth is quite small (0.031). This estimate implies, for example, that 50 years after a 10 percentage point change in the trade share, average income would only be about 15 percent higher.

Finally, returning to Tables 7 and 8, it is interesting to take note of the rates of adjustment. Income adjusts quite slowly to changes in trade shares. Based on the estimates in Table 7, adjustments to trade share changes have a half-life of about 10-12 years. Income growth, however, adjusts almost immediately to its long-run level following a change in the trade share. Thus, the regressions do not perfectly differentiate the effects of trade on income from those effects on income growth. The "level" regressions indicate large and statistically significant effects on the level of income, but these effects come with a substantial adjustment period. On the other hand, the "growth" regressions indicate small and non-robust effects on income growth, but the effects on the growth rate occur immediately. However, since the levels effects seem relatively robust to various regression specifications, we can be more confident that the estimated effect of a change in trade is associated with a change in average income rather than in average income growth.

We now consider the robustness of these results to the specification of the trade instrument. Recall that in the previous section, three alternative measures of the trade instrument were constructed, in addition to the basic specification. We re-estimated the models in (4) and (5) using these alternative specifications. The results for the IV estimates only are presented in Table 10. For comparison, the first column of the table shows the estimated long-run effects based on using the basic specification of the trade instrument. These estimates are the same as those shown in the last column of Table 9. Columns (2) through (4) of Table 10 show the estimated long-run effects of trade based on using the three alternative trade measures. Surprisingly, the estimates are relatively robust to the trade instrument specification.

In summary, there is fairly conclusive evidence that trade changes have permanent effects on the level of average income. The estimated effects of a one percentage point change in the trade share on average income ranges from 0.7 to 1.2 percent. These estimates are statistically different from zero, and they are robust to a number of model specifications. In contrast, the estimated effects of trade on income growth are quite small and are not robust to model changes.

V. Conclusions

Most economists agree that increased trade leads to an increase in the level of average income, as country resources are reallocated more efficiently. They do not seem to agree on whether trade can influence the long-run growth rate of the economy. Indeed, while many studies have found a positive relationship between trade and income or between trade and income growth, these relationships are generally not robust.

Most of these studies used cross-sectional methods, where income or income growth was regressed on trade measures. In this paper, we have argued that these relationships can be tested only using a panel data model. Since trade and income are both likely to be endogenous variables, we also extended Frankel and Romer's instrumental variable approach to the case of a panel data model. This instrument is based on geography variables, which are highly correlated with trade but are unlikely to affect income other than through international trade. In addition, we constructed some alternative instruments in order to assess the robustness of the instrumental variable approach.

The parameter estimates from the panel data models are consistent with those obtained by Frankel and Romer and by Irwin and Terviö. However, importantly, the panel data models are able to distinguish between the effects of trade on income and the effects of trade on income growth. The results indicate that a one percentage point change in trade is associated with a one percentage point change in average income. This estimate is both significant from zero and robust to changes in the econometric specification. On the other hand, the estimated effect of trade on income growth is quite small, and the estimated relationship is not robust to model specification.

Table 1. The Order of Integration and the Long-run Derivative

	Order of Integration of:				
	TRD	y	Δy	$LRD_{y,x}$	$LRD_{\Delta y,x}$
i)	0	—	—	undefined	undefined
ii)	1	0	—	0	0
iii)	1	1	—	β_y	0
iv)	1	2	1	∞	$\beta_{\Delta y}$

Table 2. Augmented Dickey-Fuller Tests of Trade Shares and Average Income

(Number of rejections out of 125 countries, 1969-92)

Variable (X)	H_0: X is I(1)		H_0: X is I(2)
	Without Trend	With Trend	Without Trend
Trade Shares	4	4	116
Estimated Trade Shares	2	3	125
Log Real GDP Per Capita	6	1	90

Table 3. List of 35 Countries and Areas Where Average Income Appears to Be I(2)

Barbados	Japan
Belgium	Mauritius
Bolivia	Mozambique
Brazil	Netherlands
Cameroon	Norway
Canada	Panama
Colombia	Portugal
Congo, Rep. of	Puerto Rico
Czechoslovakia	Romania
Ecuador	Saudi Arabia
France	Singapore
Greece	South Africa
Guatemala	Spain
Haiti	Suriname
Indonesia	Togo
Iran, Islamic Rep. of	Tunisia
Côte d'Ivoire	Yugoslavia
Jamaica	

Table 4. Bilateral Trade Regression Results

	(1) -- Basic		(2)		(3)		(4)	
	Equal to Each Other?	Equal to Zero?	Equal to Each Other?	Equal to Zero?	Equal to Each Other?	Equal to Zero?	Equal to Each Other?	Equal to Zero?
Time Dummies	0.56	**0.00**	0.72	**0.00**	0.90	**0.00**	0.16	**0.00**
Log Distance	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.98	**0.00**
Log Population(i)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Log Population(j)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.83	**0.00**
Log Area(i)	0.77	**0.00**	0.76	**0.00**	0.92	**0.00**	**0.01**	**0.01**
Log Area(j)	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	0.67	**0.00**
Landlocked	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	1.00	**0.00**
Income Differences	–		**0.00**	**0.00**	**0.00**	**0.00**	--	
Language Dummies	–		--		**0.00**	**0.00**	--	
Common Border	1.00	0.24	1.00	0.71	1.00	0.53	1.00	**0.00**
Common Border * Log Distance	**0.03**	**0.00**	**0.02**	**0.00**	**0.02**	**0.00**	1.00	1.00
Common Border * Log Pop(i)	0.84	**0.00**	0.84	**0.00**	0.88	**0.00**	1.00	**0.00**
Common Border * Log Pop(j)	1.00	0.81	1.00	0.85	1.00	0.85	1.00	**0.00**
Common Border * Log Area(i)	0.92	**0.00**	0.93	**0.01**	0.92	**0.00**	0.99	**0.00**
Common Border * Log Area(j)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	**0.00**
Common Border * Landlocked	0.89	**0.00**	0.97	**0.00**	0.98	**0.00**	1.00	1.00
Common Border * Income Differences	--		1.00	1.00	1.00	1.00	--	
Number of Regressors	462		528		536		462	
Number of Observations	88,160		87,827		87,827		7,541	
Sigma Squared	2.9368		2.9097		2.8356		0.7252	

Notes: Specifications (1)-(3) use data for all countries in the sample. Specification (4) uses data for OECD countries only.
Bolded numbers indicate significance from zero at the 5 percent confidence level.

Table 5. The Estimated Effects of Trade on GDP Per Capita

$$y_{it} = \mu_i + \mu_t + \beta_y \, TRD_{it} + \lambda \, Z_{it} + \varepsilon_{it} \quad (1)$$

a) estimates using OLS

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Trade Share	**0.825**	**18.17**	**0.625**	**26.59**	**0.363**	**17.61**
Log Population	**0.174**	**14.14**	**0.448**	**25.66**	**-0.665**	**-21.75**
Log Area	**-0.042**	**-4.09**	---		---	
Constant	**586.310**	**53.46**	**349.962**	**19.94**	**1509.975**	**47.43**
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	4083		4083		4083	
Sigma Squared	9289.91		504.20		337.24	

b) estimates using IV

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Trade Share	**2.815**	**23.81**	**0.673**	**8.27**	0.094	1.33
Log Population	**0.143**	**12.16**	**0.629**	**35.05**	**-0.707**	**-22.07**
Log Area	-0.016	-1.57	---		---	
Constant	**614.631**	**67.23**	**185.462**	**9.93**	**1570.912**	**46.93**
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	4083		4083		4083	
Sigma Squared	8816.75		581.77		362.69	

Table 6. The Estimated Effects of Trade on GDP Per Capita Growth

$$\Delta y_{it} = \mu_i + \mu_t + \beta_{\Delta y} TRD_{it} + \lambda Z_{it} + \varepsilon_{it} \quad (2)$$

a) estimates using OLS

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Trade Share	**0.011**	**3.47**	**0.018**	**2.72**	**0.027**	**3.81**
Log Population	**0.004**	**5.21**	**-0.057**	**-11.39**	**-0.037**	**-3.57**
Log Area	**-0.004**	**-5.22**	---		---	
Constant	-0.844	-1.13	**59.041**	**11.72**	**38.836**	**3.55**
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	3958		3958		3958	
Sigma Squared	41.62		37.94		36.82	

b) estimates using IV

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Trade Share	**0.022**	**2.72**	0.011	0.53	0.010	0.43
Log Population	**0.004**	**4.64**	**-0.052**	**-10.88**	**-0.038**	**-3.63**
Log Area	**-0.004**	**-5.36**	---		---	
Constant	0.089	0.14	**54.462**	**10.95**	**40.806**	**3.71**
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	3975		3975		3975	
Sigma Squared	41.72		38.06		37.01	

Note: Numbers in bold indicate that estimate is significant from zero at the 5% level.

Table 7. The Estimated Effects of Trade on GDP Per Capita

$$\Delta y_{it} = \mu_i + \mu_t + \rho(y_{it-1} - \beta_y TRD_{it-1}) + \delta_y \Delta TRD_{it-1} + \lambda Z_{it} + \varepsilon_{it} \quad (4)$$

a) estimates using OLS

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Log of GDP_{-1}	**-0.002**	**-2.09**	**-0.062**	**-14.47**	**-0.055**	**-10.59**
Trade $Share_{-1}$	**0.009**	**3.37**	**0.045**	**5.73**	**0.056**	**7.09**
GDP $Growth_{-1}$	**0.130**	**8.15**	**0.088**	**5.64**	**0.065**	**4.05**
Change in Trade Share	0.025	1.94	**0.034**	**2.61**	0.021	1.61
Change in Trade $Share_{-1}$	**0.053**	**4.12**	**0.034**	**2.63**	**0.030**	**2.25**
Population Growth	**-0.828**	**-10.96**	**-0.953**	**-10.85**	**-0.941**	**-10.80**
Constant	**4.458**	**4.89**	**52.748**	**14.76**	**46.055**	**10.25**
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	3833		3833		3833	
Sigma Squared	40.09		36.08		34.95	

b) estimates using IV

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Log of GDP_{-1}	**-0.002**	**-2.11**	**-0.061**	**-14.30**	**-0.055**	**-10.56**
Trade $Share_{-1}$	**0.008**	**3.33**	**0.040**	**5.29**	**0.053**	**6.85**
GDP $Growth_{-1}$	**0.132**	**8.31**	**0.090**	**5.81**	**0.068**	**4.26**
Change in Trade Share	**0.085**	**2.96**	**0.080**	**2.92**	0.035	1.21
Change in Trade $Share_{-1}$	**0.054**	**4.14**	**0.036**	**2.80**	**0.031**	**2.34**
Population Growth	**-0.820**	**-10.85**	**-0.945**	**-10.76**	**-0.935**	**-10.72**
Constant	**4.472**	**4.91**	**51.922**	**14.61**	**45.993**	**10.25**
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	3839		3839		3839	
Sigma Squared	40.10		36.12		35.01	

Table 8. The Estimated Effects of Trade on GDP Per Capita Growth

$$\Delta^2 y_{it} = \mu_i + \mu_t + \rho(\Delta y_{it-1} - \beta_{\Delta y} TRD_{it-1}) + \delta_{\Delta y} \Delta TRD_{it-1} + \lambda Z_{it} + \varepsilon_{it} \quad (5)$$

a) estimates using OLS

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
GDP Growth$_{-1}$	**-0.828**	**-38.79**	**-0.918**	**-41.63**	**-0.992**	**2.85**
Trade Share$_{-1}$	**0.007**	**2.78**	-0.013	-1.80	**0.034**	**3.18**
Change in GDP Growth$_{-1}$	**-0.051**	**-3.16**	-0.007	-0.43	**0.027**	**2.98**
Change in Trade Share	0.025	1.89	0.012	0.91	**0.015**	**3.10**
Change in Trade Share$_{-1}$	**0.056**	**4.17**	**0.062**	**4.64**	**0.043**	**2.40**
Population Growth	**-0.773**	**-10.85**	**-0.902**	**-9.93**	**-0.939**	**3.13**
Constant	**2.525**	**10.22**	**3.942**	**3.26**	**0.640**	**3.95**
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	3708		3708		3708	
Sigma Squared	40.03		37.99		35.84	

b) estimates using IV

	(1)		(2)		(3)	
	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
GDP Growth$_{-1}$	**-0.826**	**-38.75**	**-0.916**	**-41.62**	**-0.988**	**-43.91**
Trade Share$_{-1}$	**0.007**	**2.72**	**-0.014**	**-2.01**	**0.031**	**4.03**
Change in GDP Growth$_{-1}$	**-0.052**	**-3.19**	-0.007	-0.43	0.027	1.69
Change in Trade Share	**0.086**	**2.97**	**0.082**	**2.89**	0.034	1.16
Change in Trade Share$_{-1}$	**0.056**	**4.18**	**0.063**	**4.72**	**0.045**	**3.23**
Population Growth	**-0.764**	**-10.72**	**-0.896**	**-9.87**	**-0.933**	**-10.48**
Constant	**2.522**	**10.23**	**3.968**	**3.29**	0.750	0.56
Country Dummies?	No		Yes		Yes	
Time Dummies?	No		No		Yes	
Number of Observations	3714		3714		3714	
Sigma Squared	40.04		37.98		35.91	

Note: Numbers in bold indicate that estimate is significant from zero at the 5% level.

Table 9. Summary of Estimated Long-Run Trade Effects
(based on estimated coefficients from Tables (7) and (8))

Estimated Effect On:	Dummies Included	Estimated LR Elasticity: Using OLS	Using IV
GDP Per Capita	None	**3.643**	**3.560**
	Country	**0.715**	**0.650**
	Country and Time	**1.016**	**0.953**
GDP Per Capita Growth	None	**0.008**	**0.008**
	Country	-0.008	**-0.015**
	Country and Time	**0.028**	**0.031**

Note: Numbers in bold indicate that estimate is significant from zero at the 5% level.

Table 10. Long-Run Trade Effects – Robustness Checks

Estimated Effect On:	Dummies Included	Estimated LR Elasticity: (1) - Basic	(2)	(3)	(4)
GDP Per Capita	None	**3.560**	**3.497**	**3.523**	-0.099
	Country	**0.650**	**1.479**	**0.642**	**0.600**
	Country and Time	**0.953**	**1.222**	**0.952**	**0.698**
GDP Per Capita Growth	None	**0.008**	**0.008**	**0.008**	-0.009
	Country	-0.015	**-0.016**	**-0.016**	**-0.061**
	Country and Time	**0.031**	**0.031**	**0.031**	**0.050**

Note: Numbers in bold indicate that estimate is significant from zero at the 5% level.

Figure 1. Trade Share and GDP Per Capita
(Annual observations for 125 countries, 1960-92)

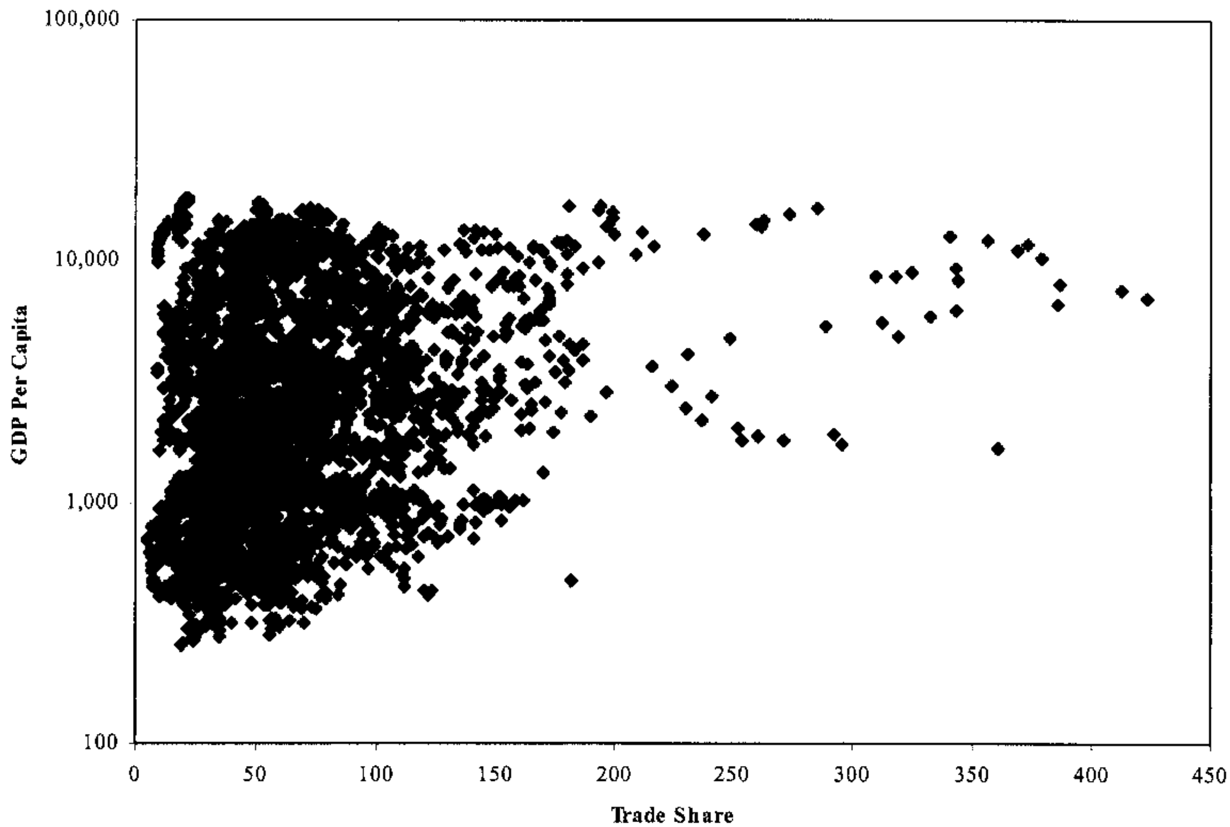


Figure 2. Trade Share and GDP Per Capita Growth
(Annual observations for 125 countries, 1960-92)

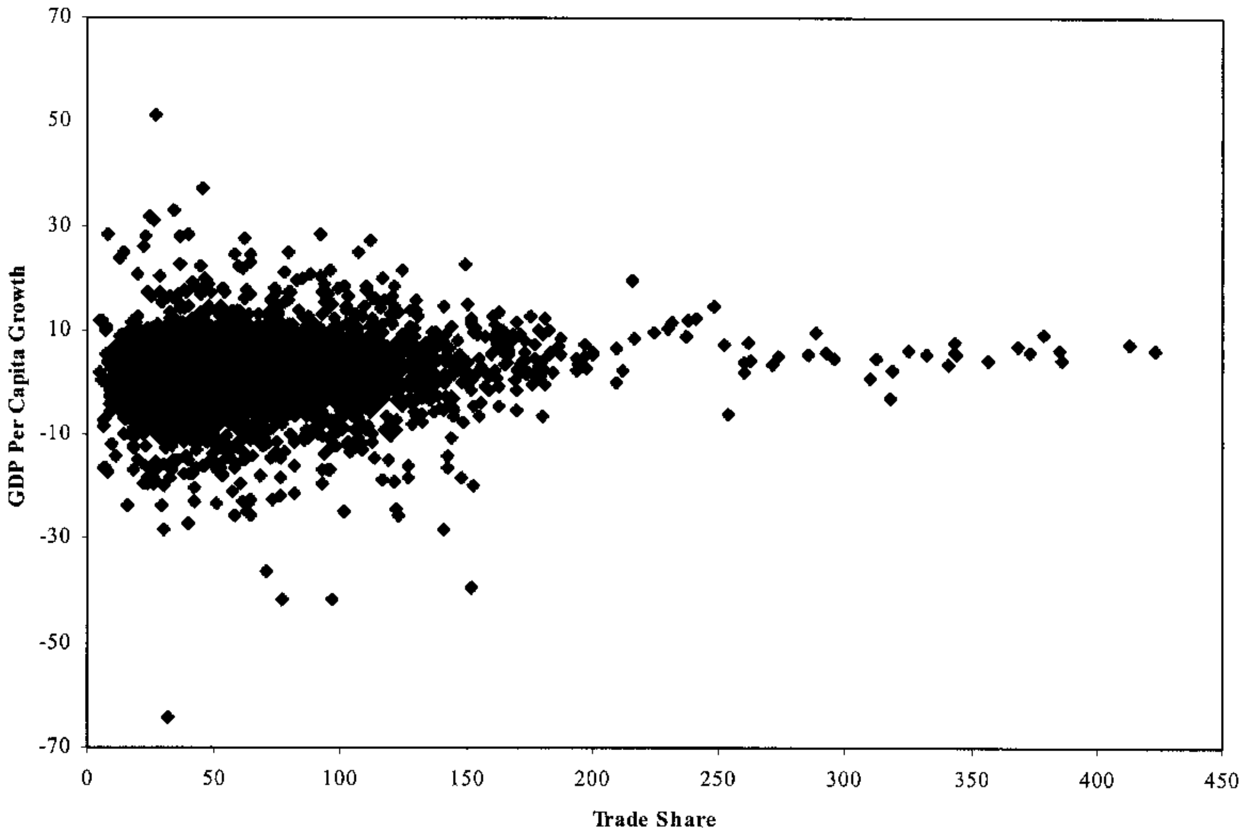


Figure 3. The Possible Effects of Increased Trade on Income

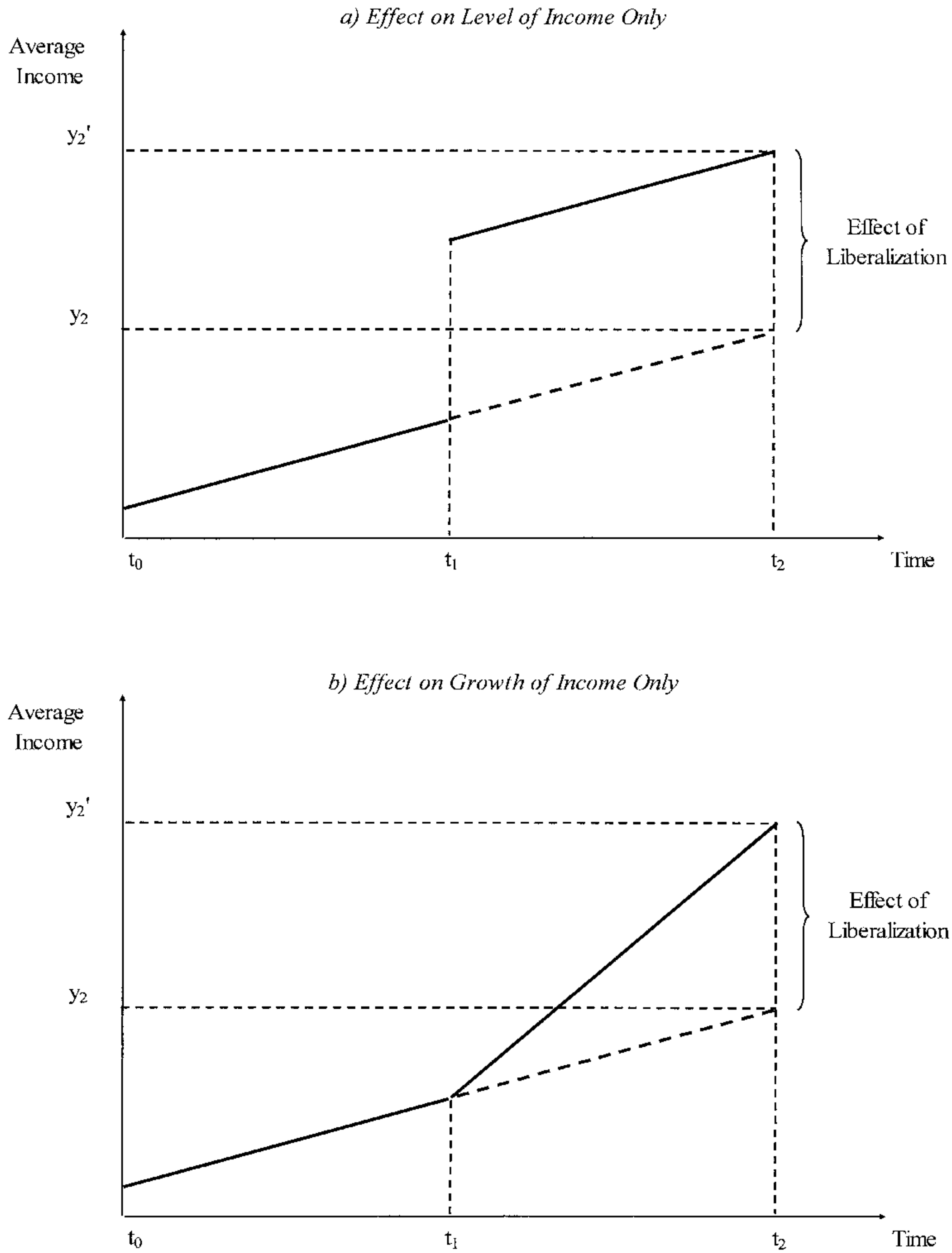


Figure 4. Effects of Time Dummies on Bilalteral Trade Shares
(Estimated Coefficients from Basic Specification)

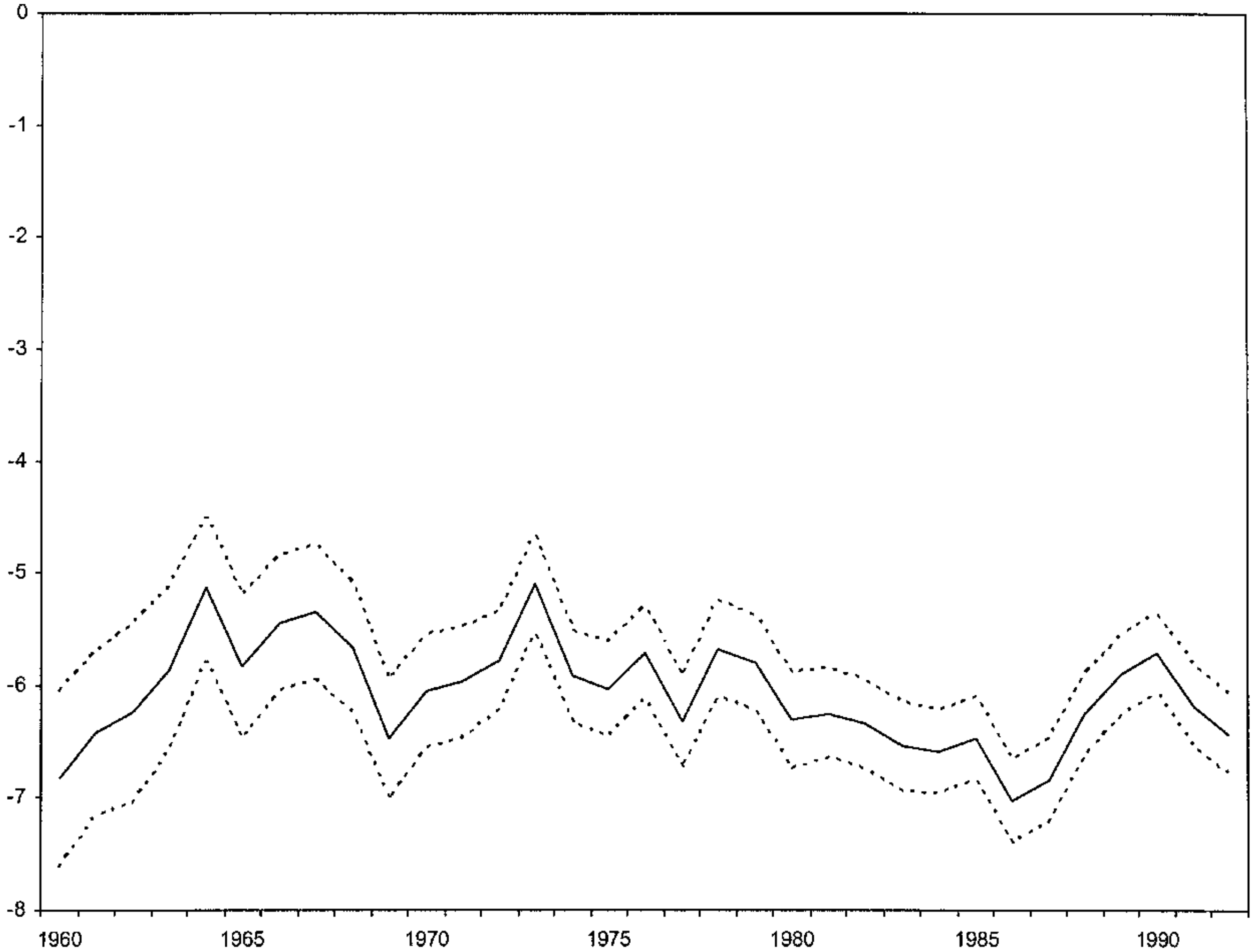


Figure 5. Effects of Distance on Bilateral Trade Shares
(Estimated Coefficients from Basic Specification)

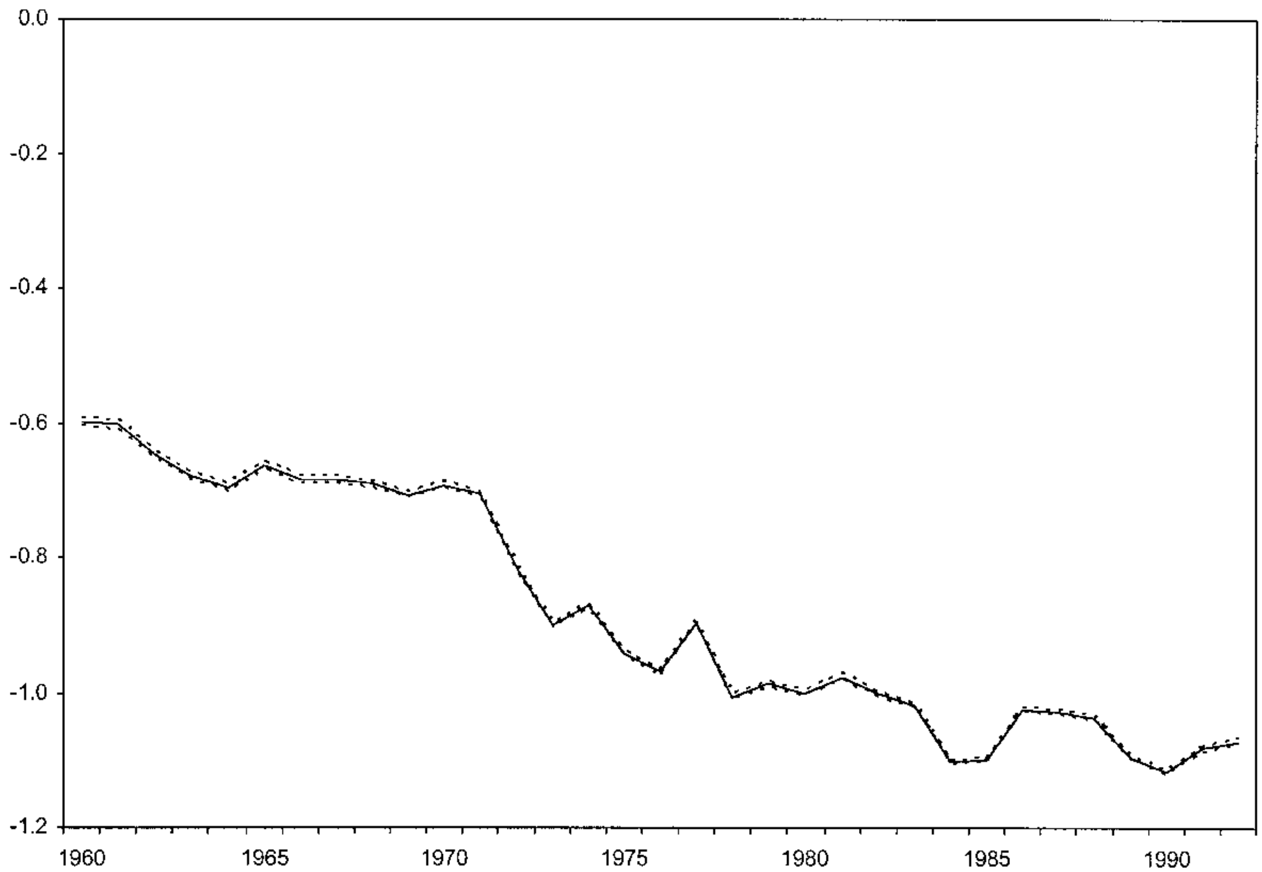


Figure 6. Effects of Population on Bilateral Trade Shares
(Estimated Coefficients from Basic Specification)

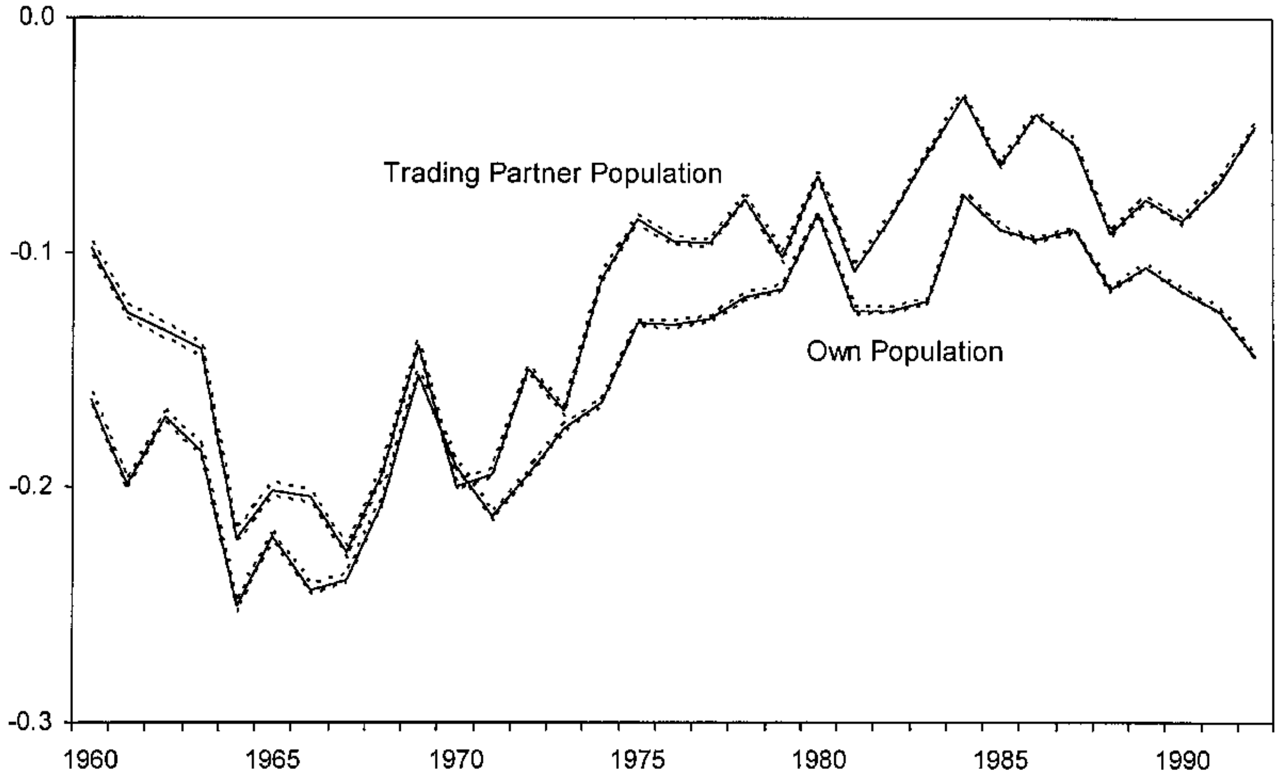


Figure 7. Effects of Area on Bilateral Trade Shares
(Estimated Coefficients from Basic Specification)

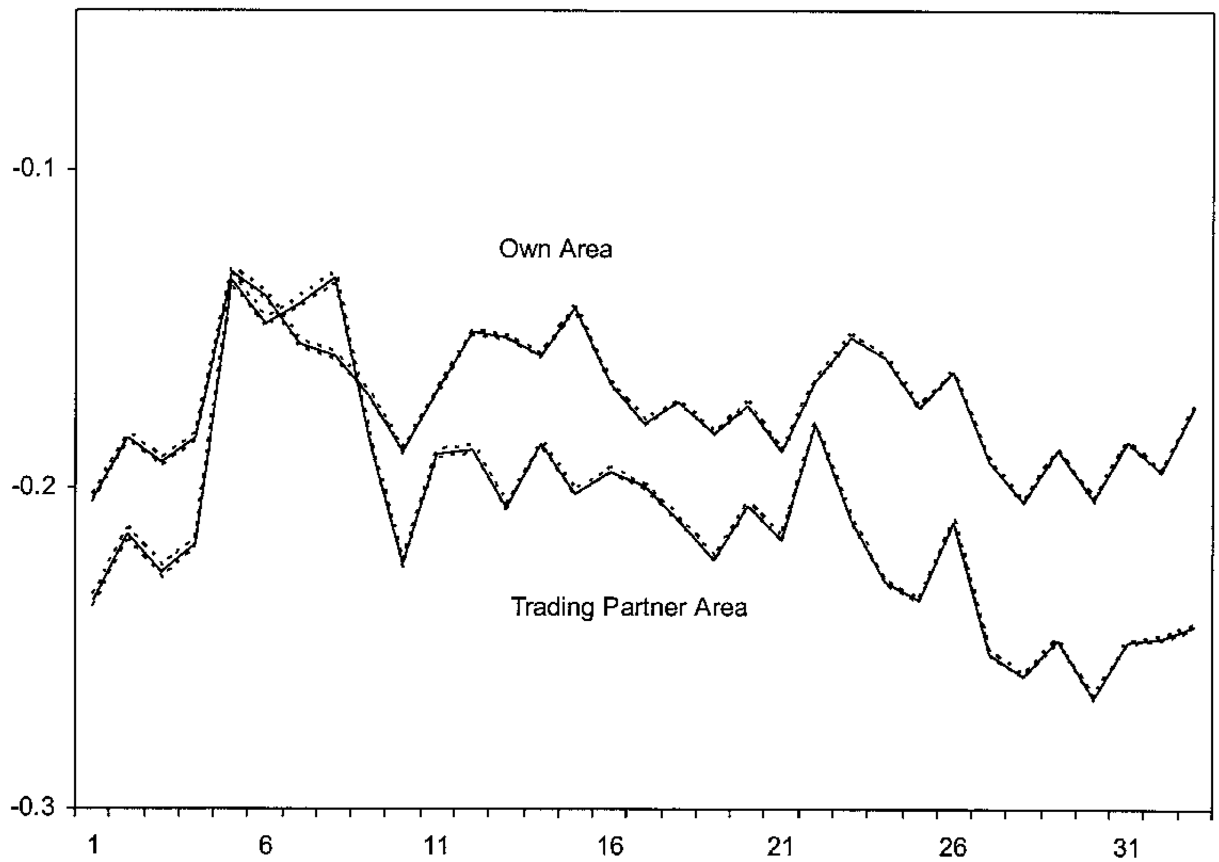


Figure 8. Effects of Landlocked Dummies on Bilateral Trade Shares
(Estimated Coefficients from Basic Specification)

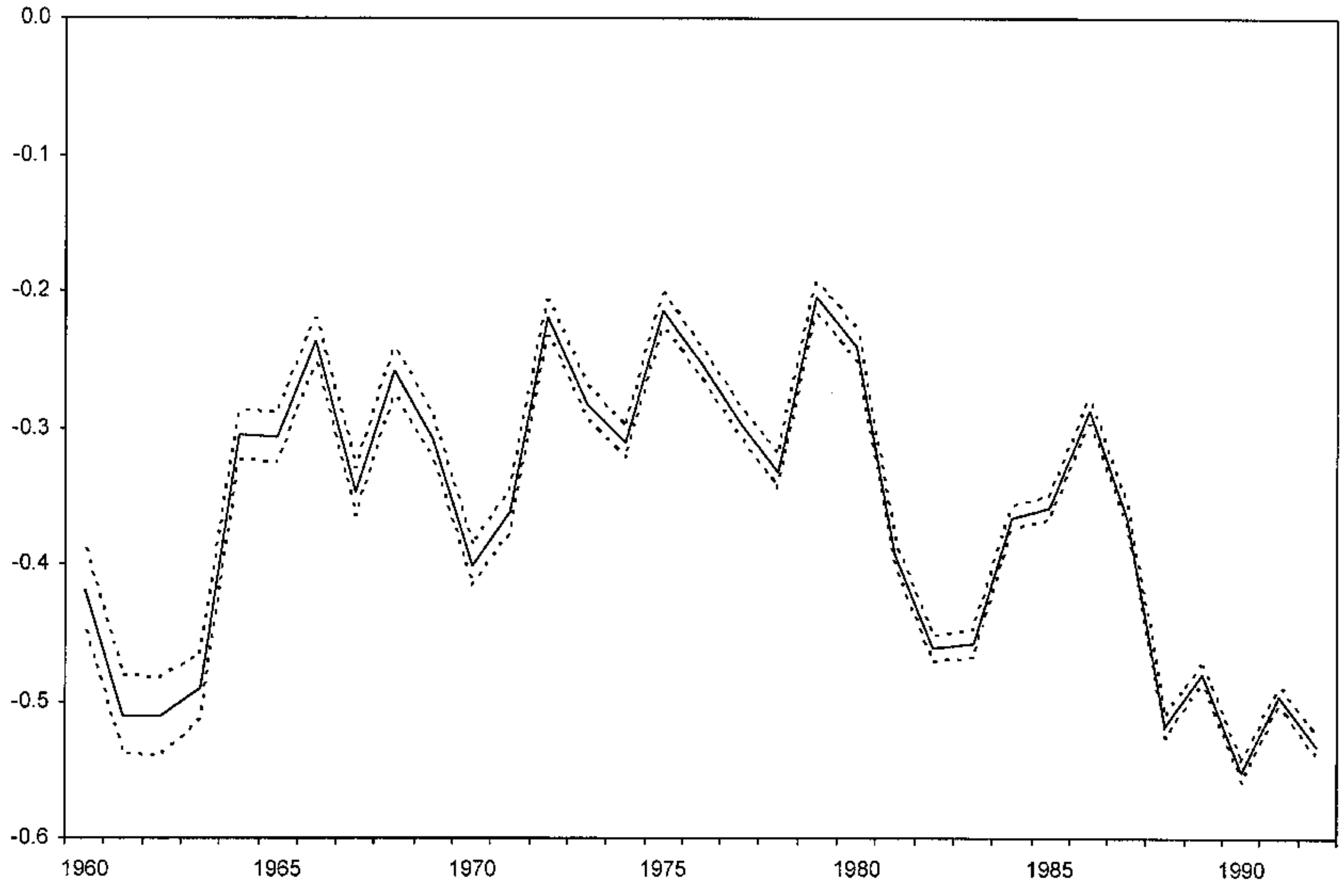


Figure 9. Effects of Common Border Dummies on Bilateral Trade Shares
(Estimated Coefficients from Basic Specification)

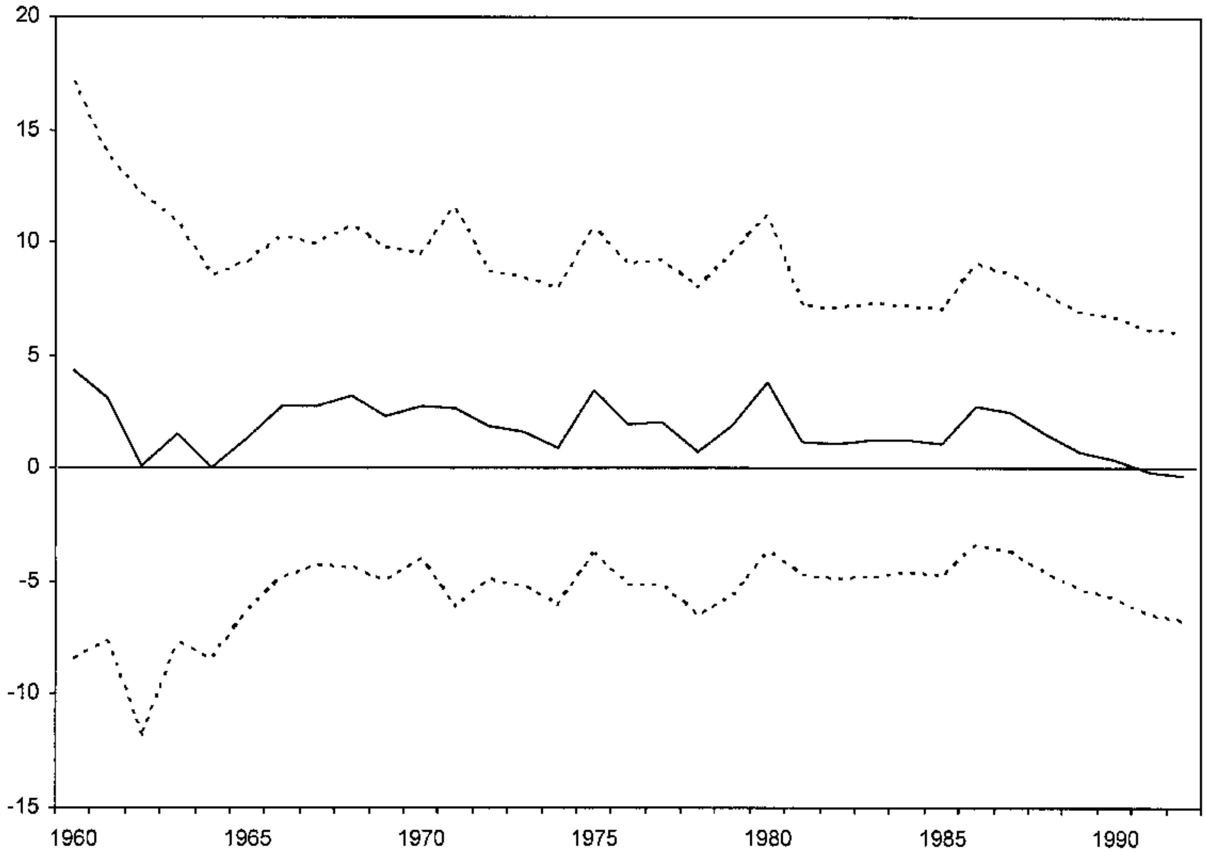
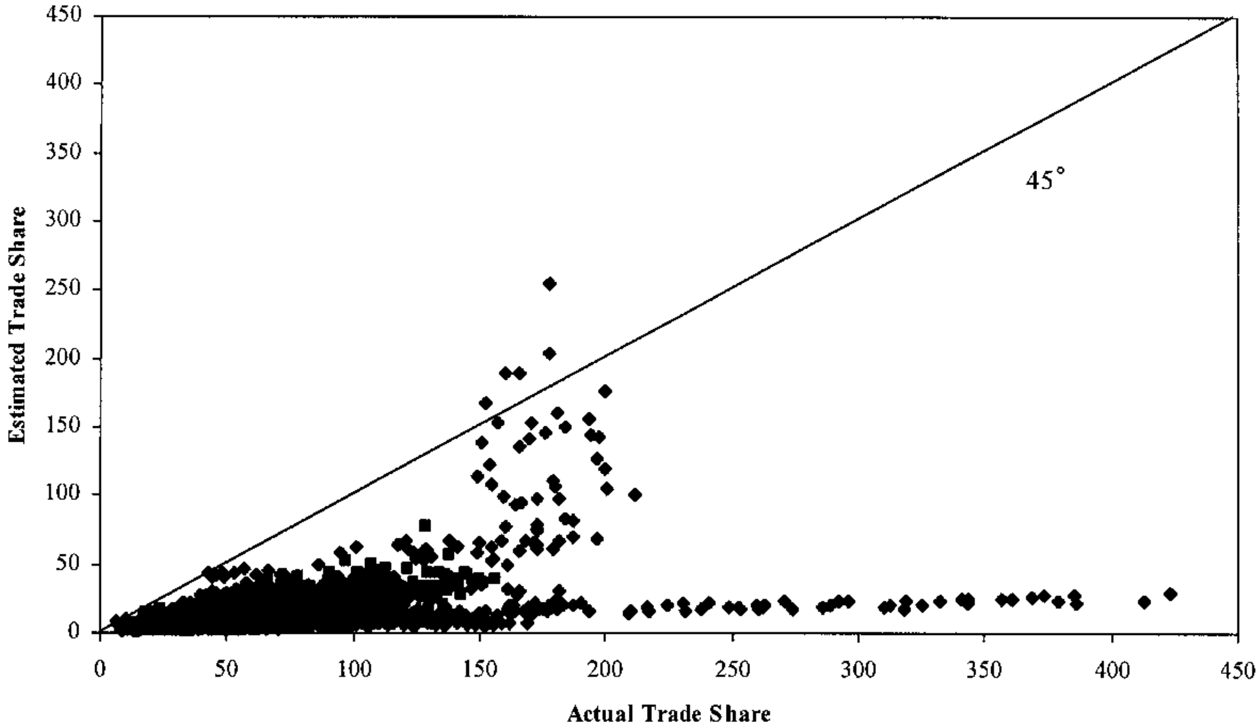


Figure 10. Actual and Estimated Trade Shares



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