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INTERNATIONAL TRADE AND PER CAPITA INCOME CONVERGENCE: A DIFFERENCE-IN-DIFFERENCES ANALYSIS

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ABSTRACT

In this paper I analyze whether international trade contributes to per capita income convergence across countries. The analysis focuses on four important post-1945 multilateral trade liberalizations. To identify trade's effect on income dispersion, in each case I use a "difference-in-differences" approach which compares the convergence pattern among the liberalizing countries before and after liberalization with the convergence pattern among randomly chosen control countries before and after liberalization. My main empirical result is that trade liberalization did not trigger convergence in any of the four cases. If anything, trade seems to have caused income divergence.

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1 Introduction

Does international trade cause per capita income convergence across countries? Trade theory offers an ambiguous answer: trade can either converge or diverge incomes. In this paper I offer new empirical evidence on this question based on four important post-1945 trade liberalizations.

To identify trade's effect on income dispersion, in each of the four cases I use a "difference in differences" methodology which compares the convergence pattern among the liberalizing countries before and after liberalization with the convergence pattern among randomly chosen control countries before and after liberalization. In each case I identify trade's role as the estimated difference in differences of convergence rates pre- and post-liberalization between the two groups of countries. To gauge the robustness of results to the control countries, for each case I estimate 10,000 difference-in-differences by redrawing a new set of control countries each time.

The central contribution of this paper is its difference-in-differences methodology. The few existing empirical studies focusing on trade and income convergence attempt to identify trade's effect through only a single comparison (at most) of two groups of countries. All these studies argue that their single comparisons support the hypothesis that trade converges incomes. However, as I discuss below these single comparisons are actually consistent with either convergence or divergence. The difference-in-differences approach is explicitly designed to overcome the potential ambiguities of the single-difference studies.

My main empirical result is that trade liberalization did not trigger convergence in any of the four cases. If anything, trade seems to have caused income divergence. I initially analyze just the single difference of the convergence pattern within each liberalizing group before and after liberalization. All four cases display convergence pre-liberalization, but in no case did convergence accelerate post-liberalization. In one case it continued at the same rate, in another case it decelerated significantly, and in two other cases it gave way to divergence. The difference-in-differences analysis is qualitatively similar. In all four cases the large majority of the 10,000 difference-in-difference estimates are not significantly different from zero, and the average among significant estimates indicates that liberalization tends to diverge incomes.

This paper has five additional sections. Section two summarizes the theory of trade and convergence. Section three reviews related empirical work and highlights some methodological limitations which this paper improves upon. Section four outlines the difference-in-differences identification strategy. Section five presents the data and empirical results. Section six concludes.

2 Trade and Per Capita Income Across Countries: Theory

Consider a country's per capita income (pcgdp) distributed to two factors of production, labor and capital.

$$(1) \qquad pcgdp = \frac{\text{National Income}}{L} = \frac{w \times L + r \times K}{L} = w + r \times \frac{K}{L}$$

Here, L and K are the country's endowments of labor and capital and w and r are the respective national real factor prices for labor and capital. Equation (1) assumes that the total value of gross domestic output accrues to L and K and that for each factor there is one national market.

How can international trade affect convergence? Trade liberalization can influence each of the three basic determinants of national income as written in Equation (1): factor prices, factor quantities, and production technology.[1]

First, consider the factor prices w and r. The factor-price-equalization (FPE) theorem is usually defined as the set of endowment points among countries for which free trade entails not only equal goods prices across countries but also equal prices for nontradable factors as well. The theorem is essentially an international arbitrage condition. Under certain assumptions about technology and product mixes, free trade forces not just equal product prices across countries but also equal factor prices across countries as well.

As a statement about free-trade equilibria, however, the FPE theorem does not have clear predictions for cases of partial trade liberalization. Its dynamic analog is what Leamer and Levinsohn (1996) call the factor-price-convergence (FPC) theorem: "As barriers to international

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[1]This discussion expands upon a shorter discussion in Slaughter (1997). Many papers on convergence cannot analyze the role of international trade because they assume a "Solow world" in which countries producing a single aggregate good exist independent of one another (e.g., Barro and Sala-i-Martin (1992)). By construction, international linkages such as trade, factor mobility, and technology transfer don't play any role. Instead, convergence arises from per capita capital stock convergence. Identical production technologies and time preferences across countries ensure (assuming no exogenous technological progress) that all countries tend towards the same $(\frac{K}{L})$ and thus the same w and r as well. By (1), it immediately follows that all countries reach the same pcgdp level and convergence is complete.

commerce diminish, factor prices converge ... as trade in goods becomes more free, there is a tendency for factor price differentials across trading partners to be reduced." The key difference is that FPE refers to an outcome but FPC refers to a process through which freer trade can converge per capita incomes across countries.

But the FPC theorem does not predict that lower trade barriers must converge factor prices. As with the FPE theorem, whether factor prices converge also depends on cross-country tastes, technology, and endowments. Leamer (1995, p.7) comments that "by its lack of explicitness, [the FPC theorem] challenges us to find combinations of assumptions regarding factor-supply differences, technological differences, and numbers of factors and goods for which economic integration reduces international factor-price differences."

Trade liberalization can change factor prices in many ways. Samuelson (1970) demonstrates that in the standard specific-factors framework freer trade very likely generates FPC. But Deardorff (1986) presents a two-country, two-factor, four-good Heckscher-Ohlin model in which freer trade converges product prices but actually diverges factor prices. What drives this result is the assumption that certain pairs of goods are close substitutes in demand (the case is equivalent to a two-good model with a double factor-intensity reversal). Slaughter (1995) provides an empirical example of no FPC. He documents that the construction of canals and railroads in antebellum United States converged interregional commodity prices but not interregional wages.

Next, consider endowments of L and K. There is a long history of extending static Heckscher-Ohlin models to allow factor accumulation over time (see, for example, Findlay's (1984) survey). The basic result here is that trade liberalization has an ambiguous net effect on endowments across countries. In some ways liberalization converges them but in other ways it diverges them.

One important way that liberalization can converge endowments is by reducing perceived investment risk in poorer countries. Lane (1997) formalizes a model in which trade agreements signal reduced investment riskiness in countries--particularly in poorer countries which tend to be more risky initially. Post-liberalization capital accumulates more rapidly in now-less-risky poorer

countries, and all else equal this tends to converge income across countries by raising $(\frac{K}{L})$ toward richer-country levels.

In contrast, there are at least two important ways for trade liberalization to work in the opposite direction. One is through Stolper-Samuelson effects on capital rentals. Baldwin (1992) formalizes how liberalization can generate "dynamic" gains from trade for a country relatively well endowed with capital by raising its r (through the usual Stolper-Samuelson effect) and thus accelerating investment. For a country relatively poorly endowed with capital, dynamic losses from trade can result as liberalization lowers r and thus slows investment. The cross-country implication of these dynamic adjustments is divergence of relative endowments: capital-rich countries invest more while capital-poor countries invest less.

Another way freer trade can diverge cross-country endowments is by inhibiting the onset of diminishing marginal returns to investment. In a closed economy capital accumulation slows because of investment's diminishing marginal physical productivity. But with free trade, FPE implies that a country faces constant marginal returns to investment. In an open economy investment changes the national output mix as predicted by the Rybczynski theorem instead of reducing r. Trade dampens the usual closed-economy convergence mechanism. This means that richer countries do not lose their incentive to invest as soon as they would in autarky. As a result, endowments across countries need not converge. Ventura (1997) argues that this process explains South Korea's ongoing growth despite its prolonged high rates of investment.

Finally, consider technology. If countries have different levels of technology which can somehow transfer across countries, trade might be an important medium through which technology actually flows. This might happen as countries reverse engineer their imports or through the interpersonal contacts that accompany trade. Trade liberalization can thus boost technology flows.

Whatever the exact mechanism, trade-mediated technology flows change countries' real factor prices and thus per capita income. Given a country's endowment of inputs, improved technology implies higher marginal physical productivities for factors and thus higher real prices for these

factors (*assuming* fixed world product prices). To the extent that technology flows from advanced to less-advanced countries, trade liberalization helps raise factor prices in less-advanced countries up towards the factor prices in advanced countries. Krugman (1979) presents a general-equilibrium model of this equalizing flow of technology.

If technology does not flow from advanced to less-advanced countries, however, then freer trade need not converge incomes across countries. Matsuyama (1996) formalizes a model in which freer trade alters international technology flows to generate divergence across countries. Here freer trade leads poorer countries to specialize in technologically-stagnant products because they lack the resources necessary to realize agglomeration economies of high-technology products. Meanwhile, richer countries grow even richer because they focus more on the high-technology products.

In summary, trade liberalization's many effects on cross-country levels of factor prices, factor quantities, and production technology have an ambiguous net effect on cross-country income levels.

3 Trade and Per Capita Income Across Countries: Empirical Evidence

The existing evidence on trade and international income differences is mixed. There is some evidence that trade causes divergence and other evidence that it causes convergence. Moreover, the evidence on convergence is not entirely convincing because of some methodological limitations.

Bernard and Jones (1996) provide some evidence that freer trade diverges income across countries. They document that cross-country productivity levels (measured as either labor or total-factor productivity) for individual manufacturing industries since 1970 have been either not converging or even diverging. In contrast, since 1970 cross-country productivity levels in services have been converging. To reconcile these facts Bernard and Jones hypothesize that international trade might be causing the divergence: "in the tradable-goods sectors, comparative advantage leads to specialization, and to the extent that countries are producing different goods, there is no a priori reason to expect the technologies of production to be the same or to converge over time" (p. 1237).

In contrast with these results, Ben-David (1993, 1996) and Sachs and Warner (1995) present evidence linking trade to income convergence. All of them document historical episodes of income

convergence across a group of countries that were relatively "open" to each other (Sachs and Warner 1995), that liberalized trade policy among each other (Ben-David 1993), or that trade a lot with each other (Ben-David 1996). The common conclusion of these papers is that international trade causes convergence. These papers contribute to the convergence literature by explicitly testing for the role of trade. However, it is not clear how robust these tests really are.

Using several criteria, Sachs and Warner classify each country in 1970 as either "open" or "closed" to international trade. From 1970 to 1989 only in the group of open countries did the poorer countries in 1970 tend to grow faster over the next 19 years. They conclude that "*the open economies display a strong tendency towards economic convergence* ... We suggest that the most parsimonious reading of the evidence is that ... the convergence club is the club of economies linked together by international trade" (p.41).

There are two important issues about Sachs and Warner's methodology. First, they compare closed and open economies only during the period in which the countries are grouped as closed or open. They do not test how the behavior of each group individually is changed over time because of being closed or open. Suppose that during the years 1950-1969 the subsequently open group had been converging even more rapidly than they did after 1970 while the subsequently closed group had been diverging even more rapidly than they did after 1970. In this case one might conclude that openness slowed convergence.

A second issue regarding Sachs and Warner is their measurement of openness. They classify a country as either closed or open using five different criteria: non-tariff barrier coverage; tariff rates; black-market premia on exchange rates; overall economic system--socialist or capitalist; and the extent of government intervention in the export sector. A country is closed if it "fails" any one of these five criteria. Because their openness measure combines international trade, international finance, and politics it is difficult to interpret their results in terms of trade-related factors only.

Ben-David (1996) finds that from 1960 to 1989, groups of relatively wealthy countries which trade significantly among each other tend to display significant per capita income convergence relative to the convergence patterns of randomly grouped countries. He concludes that "These

findings would appear to corroborate the intuition of Heckscher and Ohlin that trade does indeed play an equalizing role" (p.294).

By separating countries solely based on trade flows, Ben-David is more likely than Sachs and Warner to identify trade's role in income convergence. But like Sachs and Warner, he compares two groups of countries (trading partners and random partners) only during the period in which the trading groups actually trade extensively. There is no effort to control for the groups' convergence patterns during some earlier period. Again, ignoring this period might miss important information.

Finally, Ben-David (1993) analyzes five episodes of post-1945 trade liberalization: formation of the European Economic Community (EEC); formation of the European Free-Trade Area (EFTA); liberalization between the EEC the EFTA; expansion of the EEC to include Denmark, Ireland, and the United Kingdom; and Kennedy-round liberalization between Canada and the United States. In all cases he finds that per capita income dispersion among liberalizing countries shrank after liberalization started. He writes that "This paper provides evidence that movement toward free trade may actually ... [be] leading to a *reduction* in income disparity across countries ... The factor price equalization [FPE] theorem provides a framework for relating trade's impact on income convergence" (p.653).

Ben-David concludes that liberalization causes convergence mainly by documenting that during liberalizations countries converged. He makes only limited attempts to compare post-liberalization convergence either to the pre-liberalization experience of liberalizers or to a set of control countries. For example, for the EEC liberalization staring in 1959, Ben-David compares the post-1959 convergence with a graph of earlier decades. He concludes that "The dispersion of real per capita incomes was fairly stable from 1870 until the mid-1950s" (p. 662). Based on his Figure VII (p. 662), this conclusion seems debatable. From about 1930 until 1940 there was convergence; then the data stop until 1950 (presumably because of World War II); and from 1950 until 1959 convergence resumed. At the very least, more formal statistical analysis of pre- and post-liberalization seems warranted. The closest Ben-David comes to doing this is Table I (p. 667) and Table III (p. 674). For various country groups (including the entire world and the 50 United

States) and time periods, he reports estimated rates of convergence of income levels towards group means. But he never explicitly matches groups during similar time periods and/or similar number of members. Moreover, he never formally tests for any differences among these rates--either within time periods across groups or within a group across time periods. The lack of clear counterfactual benchmarks makes the results somewhat difficult to interpret.

In summary, Sachs and Warner and Ben-David have been among the first to test carefully for trade's effect on income convergence. However, all these studies identify trade's effect through only a single comparison (at most) of two groups of countries. In what follows I aim to build on these studies by identifying trade's effect on convergence by using a difference-in-differences estimation strategy applied to episodes of trade liberalization.[2]

4 Empirical Strategy: Difference-in-Differences Estimation

To identify trade's effect on income convergence, one possible empirical strategy would be to derive and then estimate a set of structural equations explaining cross-country convergence in terms all relevant exogenous forces including trade liberalization. This approach be difficult to implement because it is not clear what the correct structural equations are. There is no strong consensus about how to explain growth in a single country, let alone how to explain convergence based on growth among several countries.

Instead of this structural approach, to test for trade's effect on convergence I study episodes of trade liberalization. The basic idea is that if trade causes convergence (divergence), then an exogenous movement to freer trade should accelerate this convergence (divergence) relative to what the rate would have been had liberalization not occurred. To implement this idea, the difference-in-differences methodology compares the convergence pattern among liberalizing countries pre- and post-liberalization with the convergence pattern among randomly chosen control countries pre- and

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[2]Some related studies include Mokhtari and Rassekh (1989) and Davis (1992), who test for a link between wage convergence across OECD countries and trade flows. Also, Eaton and Kortum (1995) find that growth in many OECD countries is accounted for by ideas generated in foreign countries while Coe and Helpman (1995) and Coe, Helpman, and Hoffmaister (1997) present evidence that trade mediates the flow of these ideas and their impact on total factor productivity. However, none of these studies focuses directly on trade and income convergence as do the papers discussed in this section.

post-liberalization. Trade's role is identified as the estimated difference in differences of convergence rates pre- and post-liberalization between the two groups of countries.

Meyer (1994) provides a detailed discussion of the difference-in-differences methodology. It requires data on the outcome of interest--here, per capita income dispersion across countries--during both pre- and post-liberalization for both the group of liberalizing countries and a group of "control" countries. Let the subscript j index the two groups of countries: j=0 for the liberalizing group and j=1 for the control group. Similarly, let r index the two regimes of interest: r=0 for the pre-liberalization regime and r=1 for the post-liberalization regime. Let t index time periods; let d be a set of dummy variables (with appropriate explanatory subscripts); and let $\sigma(y)_{jrt}$ measure per capita income dispersion within each group at each point, where y is log per capita incomes. Given this notation, the difference-in-differences model to be estimated can written as follows.

$$(2) \qquad \sigma(y)_{jrt} = a_1 + a_2(d_r) + a_3(d_j) + a_4(d_{jr}) + b_1(t) + b_2(t)(d_r) + b_3(t)(d_j) + b_4(t)(d_{jr}) + e_{jrt} \ .$$

The dependent variable $\sigma(y)_{jrt}$ is the income dispersion for country group j during time period t which (obviously) corresponds to regime r. The white-noise additive error term is given by e_{jrt}.

For each of the four combinations of country-group/regime equation (2) estimates a separate intercept term and convergence rate for income dispersion. They are as follows.

country-group / regime	intercept	convergence rate
Liberalizing group Pre-liberalization	a_1	b_1
Liberalizing group Post-liberalization	a_1+a_2	b_1+b_2
Control group Pre-liberalization	a_1+a_3	b_1+b_3
Control group Post-liberalization	$a_1+a_2+a_3+a_4$	$b_1+b_2+b_3+b_4$

In this notation convergence (divergence) is indicated by a negative (positive) rate. The effect of trade liberalization on income convergence can be obtained by calculating the difference in differences of the estimated rates. The difference in convergence rates within the liberalizing group pre- and post-liberalization is given by $(b_1+b_2) - (b_1) = b_2$. The similar difference in convergence rates within the control group is given by $(b_1+b_2+b_3+b_4) - (b_1+b_3) = (b_2+b_4)$. Thus the difference in differences is given by $(b_2+b_4) - (b_2) = b_4$. That is, the parameter b_4 identifies the change in

convergence rates pre- and post-liberalization within the liberalizing group relative to the similar change within the control group. Assuming that the only difference pre- and post-liberalization between the two groups was the trade-policy change, then the parameter b_4 can be interpreted as identifying the effect of trade liberalization. More specifically, if trade tends to converge (diverge) incomes among the liberalizing countries then the estimated b_4 will be positive (negative).[3] Any time effect on convergence across the two regimes common to both groups of countries is captured by b_2, and any time-invariant differences in convergence between groups is captured by b_3.[4]

In equation (2) the key identifying assumption is that the only difference pre- and post-liberalization between the two groups is the trade-policy change. This is equivalent to saying that b_4 would be zero in the absence of trade liberalization. This identifying assumption means that all the unobservables not included in equation (2) have a special time-series structure in which there is no shock that affects the relative outcome of the two groups at the same time as the trade-liberalization shock. But for trade liberalization, there can be no shock affecting the relative outcome of the two groups pre- and post-liberalization. If this is not the case then $E[e_{jrt}|d_{jr}] \neq 0$ and the key identifying assumption is violated.

In true controlled experiments (e.g., new-drug trials) research design can ensure this assumption holds. But with actual trade liberalizations that are not controlled experiments, whether this assumption holds depends on what control countries are selected. One strategy might be to select a single group control countries based on some "similarity criteria" compared with the liberalizing countries. I follow an alternative strategy of randomly selecting a large number--10,000--of control groups and averaging the results from all 10,000 trials. This choice of strategy is discussed further in the following section.

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[3]For example, suppose that pre-liberalization neither group had any trend in income dispersion but that after liberalization the liberalizing group converged at a rate of -0.1 while the control group diverged at a rate of 0.1. Then the difference within the liberalizing group equals (-0.1) - (0) = -0.1. Similarly, the difference within the control group equals (0.1) - (0) = 0.1. Then the difference in differences is given by (0.1) - (-0.1) = 0.2 > 0. Trade leading to convergence is captured by a positive b_4.

[4]There is alternative way to calculate the difference in differences. First calculate the pre-liberalization difference in convergence rates between the two groups. This is given by b_3. Then calculate the post-liberalization difference in convergence rates between the two groups. This is given by b_3+b_4. Then the difference in differences is given by (b_3+b_4) - (b3), which again equals b_4.

Two additional points are worth making about this framework. First, it is instructive to compare it with the approaches of Sachs and Warner and Ben-David. Both Sachs and Warner and Ben-David (1996) compare the convergence of a group of already open (Sachs and Warner) or already trading (Ben-David) countries with a control group of closed or randomly selected countries. In terms of equation (2), these studies contrast $(b_1+b_2+b_3+b_4)$ with (b_1+b_2). This single difference (b_3+b_4) suffers the identification problem of not controlling for any differences between the two groups that may have predated the influence of openness/trade. Only if b_3 is truly zero does this approach correctly identify the role of openness/trade. Ben-David (1993) either looks just at the performance of liberalizing countries post-liberalization, i.e., at (b_1+b_2), or--informally--at this performance relative to the pre-liberalization performance, b_1. This single difference b_2 need not bear any systematic relationship to b_4. It tells the change in performance of the liberalizing countries in absolute terms but not in terms relative to some control countries.

Second, this framework assumes that trade liberalization arises independently of convergence itself--i.e., that the two are not jointly determined. This might not be the case. Perhaps countries liberalize trade primarily with countries with whom they're already converging for some non-trade reasons. Countries might do this because domestic support for trade liberalization requires that very few political-interest groups get hurt from trade. If trade liberalization with similar countries entails only small changes in product prices there will be very little internal income redistribution via the Stolper-Samuelson theorem. I have no formal way to rule out this possibility, but simply acknowledge that I treat the trade liberalizations as exogenous events.

5 Data and Empirical Results

Data

I analyze the following four cases of trade liberalization: formation of the European Economic Community (EEC); formation of the European Free-Trade Area (EFTA); liberalization between the EEC the EFTA; and Kennedy-round liberalization of the GATT. Ben-David (1993) analyzes these cases or parts thereof (for the Kennedy round he looks only at the U.S. and Canada). Two crucial requirements for using the difference-in-differences approach met by all these cases is that each

entailed substantial trade-barrier reductions and each had clear starting and ending dates. Table 1 lists for each case the participating countries and (from Ben-David (1993)) the dates and depth of liberalization.

Each agreement liberalized trade piecemeal over several years. Accordingly, I defined the post-liberalization period as running from each agreement's starting year to its ending year. Starting years include the year of first reductions if the date was June or earlier; ending years are the calendar year of the final tariff cut regardless of its month. The pre-liberalization period I defined as the period before the starting date covering the same number of years as the post-liberalization period (data permitting). Thus, for example, the EEC case's post-liberalization period was 1959 through 1968, and pre-liberalization was 1950 through 1958.

The control groups for each case I selected at random from all other countries in the world for which there is adequate data. The final column of Table 1 reports the total number of "all other countries" available for each case. For each I estimated 10,000 difference-in-differences regressions, each using a different randomly chosen set of countries equal in number to the number of liberalizing countries. I chose a large number of trials to compensate for the *a priori* uncertainty about what control countries satisfy the difference-in-differences identification assumption. As a robustness check I redid the analysis for some plausible limitations of the control-group samples. For example, for the three European liberalizing cases I tried just OECD countries. For the EEC and EFTA cases, because their liberalization periods so closely overlap I excluded each group from the other's control group. The results are qualitatively similar for these robustness checks, so for consistency all results presented below include all available countries in the control group.

Data on countries' per capita income come from the Penn World Tables assembled by Summers and Heston (1997).[5] Both real income per capita and per worker are in this data set. I used real income per worker because most convergence models assume that all the population is working. Because there is a very high sample correlation between labor forces and populations, however, results are very similar using either measure.

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[5]Summers, Robert and Heston, Alan. "The Penn World Tables, Mark 5.6," obtained from the NBER's Internet home page at http://www.nber.org, 1997.

Empirical Results

Before estimating the difference-in-difference regressions, I first estimated single-difference regressions testing whether the rates of income convergence within the liberalizing groups differed before and after liberalization. This specification is given by

$$(3) \qquad \sigma(y)_{jrt} = a_1 + a_2(d_r) + b_1(t) + b_2(t)(d_r) + u_{jrt} \ ,$$

where the variables are all as defined above and u_{jrt} is a white-noise additive error term. As discussed above, this single difference b_2 tells the change in performance of the liberalizing countries in absolute terms but not in terms relative to some control countries. Convergence (divergence) is indicated by a negative (positive) parameter estimate, such that if liberalization speeds (slows) convergence then b_2 should be negative (positive). I start with this specification to gauge liberalization's effect in the narrow context of the liberalizing groups only.

The dispersion of per worker income $\sigma(y)_{jrt}$ was calculated as the standard deviation of the log of per worker incomes for each year-country group-regime observation. This dispersion measure has been used extensively in the convergence literature, including Ben-David (1993, 1996).[6]

As a preview of the regression results for equation (3), Figures 1 through 4 plot $\sigma(y)_{jrt}$ over time for each of the four cases listed in Table 1. If trade liberalization were converging $\sigma(y)_{jrt}$, then one might expect to see convergence accelerate after each trade agreement started. None of the four cases displays obvious acceleration. Indeed, in the EEC-EFTA case convergence gave way to divergence post-liberalization. The Kennedy Round displays a similar pattern, although the range covered by $\sigma(y)_{jrt}$ in this case is much smaller partly because of fewer years of data.

Table 2 presents the regression results for equation (3) for all four cases. In none of the four cases is convergence significantly faster after liberalization starts. Instead, in three of the four cases convergence is significantly slower after liberalization. This suggests that trade liberalization did not foster convergence in any significant way; if anything, it seemed to foster divergence.

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[6]Sachs and Warner test for convergence by regressing countries' 1970-1989 annualized income growth rates on 1970 income levels: a negative coefficient indicates convergence. This measure and the Ben-David measure need not imply each other in theory even though in reality they often seem to coincide. In the terminology of Barro and Sala-i-Martin, Sachs and Warner measure "beta" convergence while Ben-David measures "sigma" convergence.

Before moving to the difference-in-difference regressions, I estimate a second set of single-difference regressions measuring convergence an alternative way. Used by Ben-David (1993), this alternative measure estimates how quickly a member country's income level is converging to the average income level of the group. First, let

$$(4) \qquad (y_{it+1} - ybar_{t+1}) = \gamma\,(y_{it} - ybar_t) \ ,$$

where y_{it} is country i's log real income per worker in year t, $ybar_t$ is the arithmetic average real income per worker among the liberalizing group in year t, and γ is a parameter relating the average income gap from one year to the next. Then define $z_{it} \equiv (y_{it} - ybar_t)$ and $\Delta z_{it+1} \equiv (z_{it+1} - z_{it})$, and equation (4) can be manipulated to obtain the following equation for estimation:

$$(5) \qquad \Delta z_{it+1} = \delta\, z_{it} + u_{it} \ ,$$

where $\delta < 0$ represents the rate of convergence of y_{it} to $ybar_t$ (with $\gamma - \delta = 1$). The larger (in absolute value) is δ, the faster is the convergence. For each case I estimate equation (5) modified to allow the parameter δ to vary before and after liberalization.

Table 3 reports the results from these regressions. The basic conclusion is the same as from Table 2: in none of the four cases is convergence significantly faster after liberalization starts. In all cases income levels were converging to group averages both before and after liberalization, but with no statistically significant difference between the two regimes.[7]

As discussed in Section 4, these single-difference results might be masking the true effect of trade liberalization. For example, in each case perhaps post-liberalization there was rapid income divergence outside the liberalizing countries. Then even though liberalization might not have accelerated convergence among the liberalizing group in absolute terms, it may very well have accelerated convergence among this group relative to what that group would have done without

[7]The results in Tables 2 and 3 are generally robust to dropping a year from or (where data permit) adding a year to the start of the pre-liberalization period and/or the end of the post-liberalization period. The only case where results changed somewhat was dropping the year 1950 from the EEC case. As figure 1 shows, the EEC group converged substantially between 1950 and 1951. If this case starts in 1951, then both the single-difference estimates in Tables 2 and 3 become significant at the 5% level. However, the 1950 results are more informative both because the additional year makes the pre-liberalization period closer in duration to the post-liberalization period and because there is no clear reason why the 1950 information should be ignored. Also, the results for the Kennedy-Round case might be less informative than the other three cases because, as Figure 4 shows, the total range of income dispersion is much smaller in this case.

liberalization as represented by the rest of the world's divergence. The difference-in-differences regressions allow for this possibility.

Table 4 reports the key results from estimating equation (2) for each case 10,000 times, each time with a different control group randomly chosen from the rest of the world. In each case, to control for initial differences in dispersion among the two groups each group's dispersion measure $\sigma(y)_{jrt}$ is scaled by the initial-year standard deviation. Again, if the key identifying assumption (discussed in section 4) holds for these regressions then b_4 can be interpreted as identifying the effect of trade liberalization on cross-country income dispersion. If trade tends to converge (diverge) incomes across countries then b_4 will be positive (negative).

The basic message of Table 4 is that trade liberalization does not appear to converge incomes across countries. The first column reports b_4 averaged across all 10,000 trials for each case. In all four cases the mean parameter estimate is negative, indicating trade tends to diverge incomes. The next column reports that for all four cases a majority of the trials (nearly 75% in three of the four cases) estimated b_4 not to be significantly different from zero. This indicates that in the majority of trials the pre- and post-liberalization convergence rates were no different among the liberalizing groups and the randomly chosen control groups. Finally, the last column reports b_4 averaged across only those trials for which b_4 was estimated significantly. In all four cases the mean parameter estimate is again negative--more so than when averaged across all trials. This indicates that on average, trade liberalization causes divergence, not convergence.

6 Conclusion

Previous empirical studies focusing on trade and income convergence all identify trade's effect through only a single comparison (at most) of two groups of countries. This paper has tried to build on these studies by identifying trade's effect on convergence by using a difference-in-differences estimation strategy applied to episodes of trade liberalization.

My main empirical result was that trade did not contribute strongly to convergence in any of the four cases I studied. I initially analyzed just the single difference of the convergence pattern within each liberalizing group before and after liberalization. All four cases display convergence pre-

liberalization, but in no case did convergence accelerate post-liberalization. The difference-in-differences analysis was qualitatively similar. In all four cases the large majority of the 10,000 difference-in-difference estimates were not significantly different from zero, and the estimates that were significant indicated that liberalization tends to diverge incomes.

Future research might explore the channels through which trade affects income dispersion. The discussion in Section 2 listed several of these channels, and with adequate data such as endowments and factor prices the difference-in-differences methodology could be applied to these questions as well.

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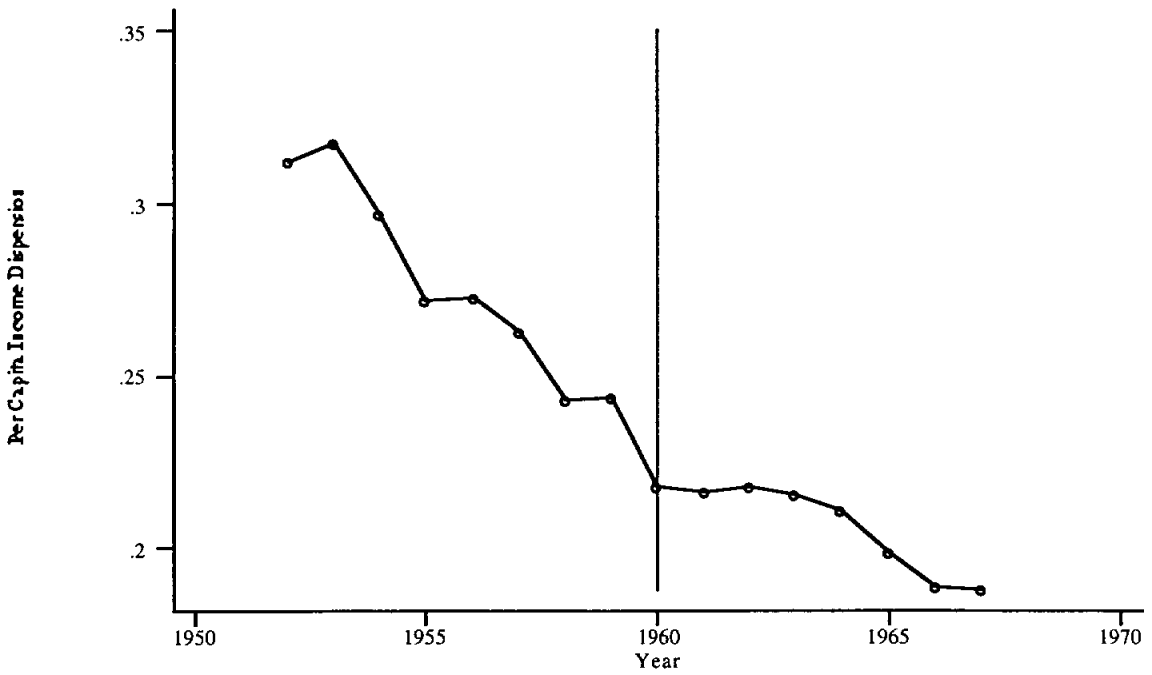
Figure 1

Case of EEC Liberalization

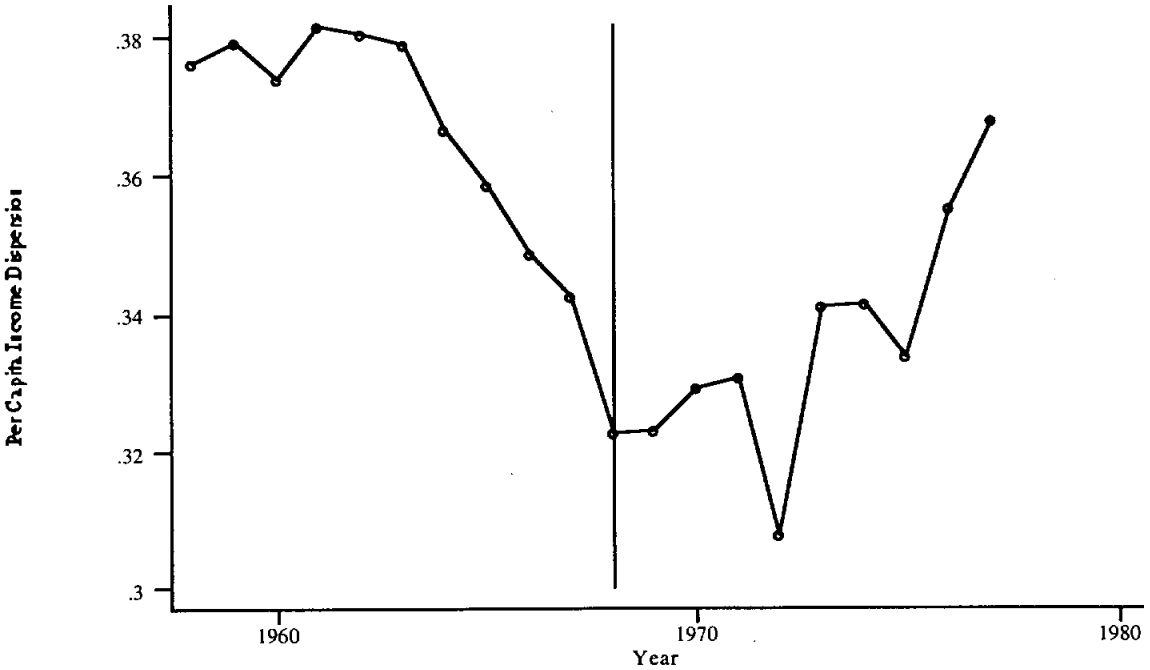
Figure 2



Case of EFTA Liberalization

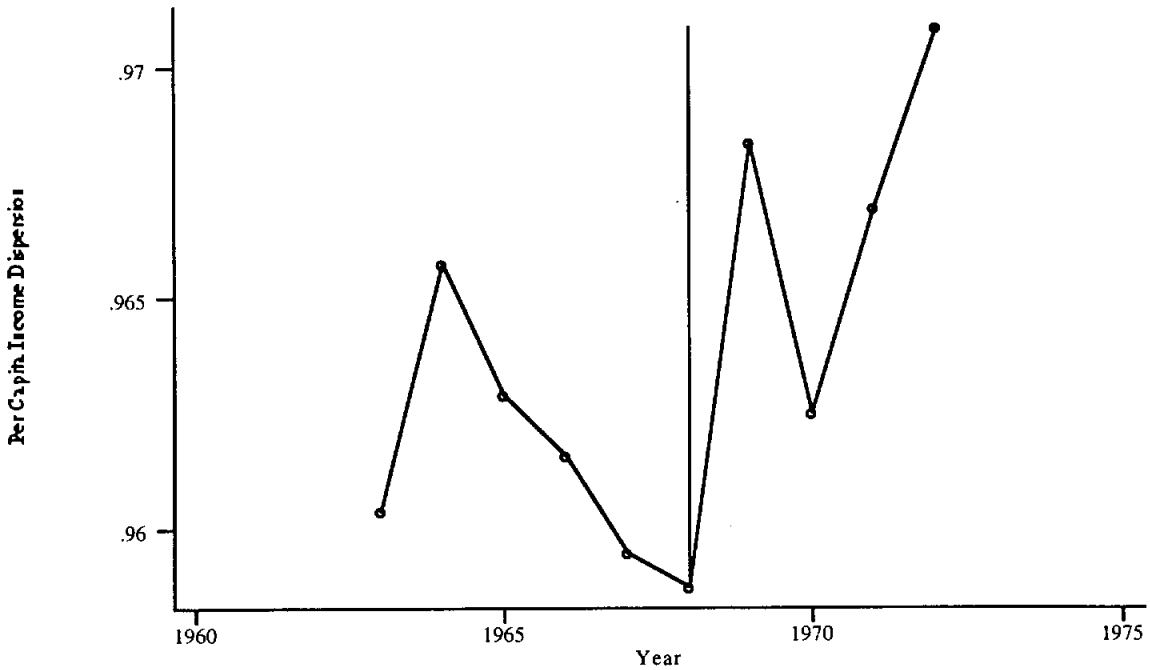
In both figures the vertical axis measures per capita income dispersion among the liberalizing countries. The measure used is the standard deviation of the natural log of per capita income.

Figure 3



Case of EEC-EFTA Liberalization

Figure 4



Case of GATT Kennedy Round Liberalization

In both figures the vertical axis measures dispersion of per capita income among the liberalizing countries. The measure used is the standard deviation of the natural log of per capita income.

Table 1
Cases of Trade Liberalization

Case Name	Liberalizing Countries	Start of Liberalization	End of Liberalization	Tariff Cuts Within Group	# of Control Countries
EEC Liberalization	Benelux, France, Germany, Italy	January-59	July-68	100%	54
EFTA Liberalization	Austria, Denmark, Norway, Portugal, Sweden, Switz., UK	July-60	January-67	100%	54
EEC-EFTA Liberalization	EEC plus EFTA	July-68	January-77	100%	60
Kennedy Round Liberalization	37 Altogether*	January-68	January-72	50%	88

* Argentina, Australia, Austria, Belgium, Brazil, Canada, Chile, Czechoslovakia, Denmark, Dominican Republic, Finland, France, Germany, Greece, Iceland, India, Israel, Italy, Jamaica, Japan, Korea, Luxemborg, Malawi, Netherlands, N. Zealand, Norway, Peru, Portugal, South Africa, Spain, Sweden, Switzerland, Trinidad and Tobago, Turkey, United Kingdom, United States, Yugoslavia.

Source : Ben-David (1993)

Table 2
Differences in Rates of Per Capita Income Convergence Pre- vs. Post-Liberalization for Liberalizing Countries

Case Name	Pre-Liberalization Convergence Rate for Liberalizers	Post-Liberalization Convergence Rate for Liberalizers	Difference in Convergence Rates	Number of Observations
EEC Liberalization	-0.008 (-4.478)***	-0.011 (-7.125)***	-0.003 (-1.216)	19
EFTA Liberalization	-0.011 (-10.850)***	-0.005 (-4.603)***	0.006 (4.417)***	16
EEC-EFTA Liberalization	-0.004 (-3.485)***	0.004 (3.923)***	0.008 (5.238)***	20
Kennedy Round Liberalization	-0.001 (-0.585)	0.002 (2.254)*	0.003 (2.007)*	10

These convergence rates are parameter estimates of the difference-in-differences regression specified in Equation (3). Reading across, the columns report the following parameters: b_1; (b_1+b_2); b_2.
T-statistics are reported in parentheses. ***, **, and * denote significance at the 99%, 95%, and 90% levels.

Table 3

Differences in Rates of Per Capita Income Convergence Pre- vs. Post-Liberalization for Liberalizing Countries

Case Name	Pre-Liberalization Convergence Rate for Liberalizers	Post-Liberalization Convergence Rate for Liberalizers	Difference in Convergence Rates	Number of Observations
EEC Liberalization	-0.059 (-3.481)***	-0.084 (-4.206)***	-0.025 (-0.872)	108
EFTA Liberalization	-0.039 (-3.381)***	-0.038 (2.631)***	0.001 (0.080)	105
EEC-EFTA Liberalization	-0.445 (-6.586)***	-0.434 (-5.622)***	0.011 (0.104)	266
Kennedy Round Liberalization	-0.594 (-9.540)***	-0.583 (-9.825)***	0.011 (0.123)	449

These convergence rates are parameter estimates of the difference-in-differences regression specified in Equation (5). T-statistics are reported in parentheses. ***, **, and * denote significance at the 99%, 95%, and 90% levels.

Table 4

Difference in Differences in Rates of Per Capita Income Convergence Pre- vs. Post-Liberalization; Liberalizing vs. Control Countries

Case Name	Average Diff-in-Diffs Estimate Among All Trials	Number of Trials With Insignificant Diff-in-Diffs Estimate	Average Diff-in-Diffs Estimate Among Significant Trials
EEC Liberalization	-0.003	7507	-0.034
EFTA Liberalization	-0.061	7523	-0.091
EEC-EFTA Liberalization	-0.027	7249	-0.067
Kennedy Round Liberalization	-0.005	5499	-0.009

In each case these results are for 10,000 trials estimating the difference-in-differences Equation (2), where each trial randomly draws a new set of control countries.
The "diff-in-diffs estimate" corresponds to parameter b_4 in Equation (2).