THE REAL-SIDE DETERMINANTS OF COUNTRIES' TERMS OF TRADE
A PANEL DATA ANALYSIS

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Introduction

Movements in a country's terms of trade have direct welfare implications. A terms of trade improvement of ten percent due to higher export or lower import prices allows a country to sell its exports for ten percent more imports on international markets. A ten-percent decrease, on the other hand, lowers its international purchasing power with the same magnitude. However, the welfare implications of changing terms of trade go beyond these direct effects, since terms of trade may also affect a country's output through its saving-investment decisions. To fully assess the welfare impact, it is therefore critical to know what causes the terms of trade to change. Yet, in spite of the prominent role that terms of trade have played in international trade theory and development economics, the actual causes of terms of trade movements are not very well understood as an empirical matter.[2] In fact, the existing empirical literature typically assumes that countries are small and that the terms of trade are exogenous.[3] [4] [5] One is left

[2] See Hadass and Williamson (2001) for a survey of the literature on the terms of trade from the classical economists till the literature in the wake of the Prebisch-Singer hypothesis.

[3] The empirical literature often investigates exogenous shocks to the terms of trade or treats the terms of trade as exogenous. In studies of the real exchange, the terms of trade are often included as a regressor, see De Gregorio and Wolf (1994); Easterly et al. (1993) and Barro and Sala-i-Martin (1995) include countries' terms of trade as an explanatory variable in their growth regressions. (Mendoza (1996) also includes the variance of the terms of trade.)

[4] Except for CGE studies such as Brown (1987), few studies go beyond time series analyses (testing the exogeneity) and explain terms of trade movements with fundamentals such as productivity increases, factor accumulation, etc. Krugman (1989) runs cross-country regressions of country export and import elasticities on growth rates to investigates whether faster growing countries avoid deteriorating terms of trade because of higher elasticities of world demand for their exports. Krugman's empirical analysis ignores supply entirely. Acemoglu and Ventura (2002) provide cross-sectional evidence that terms of trade changes are negatively related to output increases that are driven

wondering whether one can relate terms of trade movements at all to real economic determinants and whether a country has any impact on its own and others' terms of trade. It is an open question as to what extent there is empirical support for Johnson (1955) and Acemoglu and Ventura's (2002) claim that deteriorating terms of trade are just a consequence of a country's faster output expansion. [6]

In the present study we investigate what determines terms of trade movements. We relate terms of trade to changing supply and demand conditions on world markets, while taking into account the geographic dispersion of economic activity and international technology diffusion. The setup motivates a panel regression that goes beyond the existing cross-sectional evidence and explains the within-country variation of the terms of trade. Our empirical findings suggest that if factor accumulation makes a country expand faster than the rest of the world, its terms of trade will suffer. On the other hand, increasing world demand for a country's products (as measured by its market potential) has a positive impact. Our empirical analysis also suggests a modified version of the Prebisch-Singer hypothesis. We provide evidence that countries have ways to avoid adverse terms of trade effects by upgrading the quality and varieties of their output. In other words, secularly declining terms of trade are only expected in those countries that steadily fail to innovate. Moreover, significant quality/variety upgrading effects suggest that the terms of trade cannot be the only mechanism to stabilize the world income distribution, i.e. to slow down fast growers and stimulate slower countries.[7]

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by capital accumulation. Our findings complement and extend their results. We study the within-country variation with panel data, more observations and in a richer setting that takes into account technology spillovers and the changing geographic dispersion of demand.

[5] There is an extensive literature on purchasing power parity, see Froot and Rogoff (1995). The part of this literature that uses structural models focuses on the international differences between traded and non-traded goods prices, and how these explain the real exchange rate. This debate goes back to Balassa (1964) and Samuelson (1964). Note that the ratio of traded vs. non-traded goods prices is routinely referred to as the 'terms of trade' in this literature, which differs from the ratio of export over import prices that we study.

[6] In the international trade literature, the 'optimal tariff argument' suggests that big countries can set their terms of trade favorably through their tariff policy. We do not explicitly test this hypothesis here, we do allow trade policy to affect countries' import demand in the empirical implementation.

[7] Hummels and Klenow (2001) come to a similar conclusion in their discussion of Acemoglu and Ventura (2002). They suggest diminishing returns and technology spillovers as alternative sources.

When countries produce different homogenous products, many international trade theories predict that output expansion due to technological progress or factor accumulation worsens a country's terms of trade. This result is clearly observed in the Ricardian model by Dornbusch, Fischer and Samuelson (1977), its adaptation by Krugman (1985), a Heckscher-Ohlin model with complete specialization, or whenever the Armington (1969) assumption is used to distinguish goods by country of origin. The intuition for declining terms of trade is straightforward. To sell additional output on world markets, all else equal, a country slides down the world demand for its products and lowers its export price. Alternatively, if more output means more income and higher import demand, import prices will rise.[8] To investigate this hypothesis empirically poses a challenge, since it can only be tested jointly with the setting that is chosen. However, there exist not one model of the world economy that everybody will agree upon and it is not possible to address all issues in this world economy at once, so some degree stylization is necessary.

We opt to build on the established empirical literature in trade (for demand) and on production function estimation (for supply). Both literatures provide a fairly flexible setting. They allow us study this under-researched topic while controlling, on the basis of the currently available research, for a variety of issues that themselves still merit further independent study (i.e. trade policy, technological change, etc.). At the same time, the two approaches are flexible enough to avoid that we are too narrowly tied to one particular view of the world.[9] Note that we are bound to work with variables that measure production and prices at an aggregate level since we study a wide range of countries over an extended period of time. This poses, as Krugman (1989) recognized, a challenge that is particularly relevant for the question that we investigate.

Krugman (1989) has argued that changing quality or increasing/decreasing varieties may have nontrivial consequences for a country's overall terms of trade. He shows how output increases

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[8] The Bhagwati-Johnson hypothesis is an alternative hypothesis. It posits that when countries produce the same goods, as in the Heckscher-Ohlin world of Trefler (1995) or Debaere (2002), the effect of a country's output expansion on its terms of trade depends on the export or import bias of the output expansion. We are investigating this alternative hypothesis with sectoral data in Debaere and Lee (2002).

do not necessarily lead to decreasing terms of trade if they take the form of more production and exports of new varieties (or higher-quality goods).[10] In this case an increase in a country's aggregate supply (with unobserved increasing product variety) will be accompanied by rising demand for the country's goods and an improvement in its terms of trade. For an empirical study, this raises the need to control for changing varieties/quality. To address this issue, we rely on Feenstra (1994) who studied the particular measurement bias in price indices that do not take changing varieties and qualities into account. In addition, we propose two proxies to control for changing varieties and qualities. The micro studies of Funke and Ruhwedel, (2001), Schott, (2002), Hummels and Klenow, (2001) and Hallak, (2002) document a strong correlation between per capita GDP and increasing product quality/varieties. This is consistent with new trade theory that predicts intra-industry trade (in product varieties) esp. among industrialized countries and also with Flam and Helpman (1987) who expect higher quality products in richer countries. Finally, next to per capita GDP we choose the stock of (business) R&D to proxy for international differences in quality/variety, since a significant fraction of business R&D is spent on product development/innovation.[11] Moreover, Grossman and Helpman's (1991) quality ladder and expanding variety models explicitly relate increasing varieties/quality to R&D spending.

Our empirical results show that an increase in a country's per capita GDP relative to its trading partners has a fairly strong, positive impact on the terms of trade, and so have productivity improvements induced by foreign and domestic R&D. Since both measures are related to changing varieties/quality in the theoretical and empirical literature, our evidence suggests that fast output expansion need not necessarily imply a drastic drop in a country's terms of trade. Countries can circumvent adverse terms of trade effects as long as they upgrade the quality and/or varieties of their output.

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[9] Our approach differs thus markedly from Acemoglu and Ventura who approach the terms of trade question in the context of the growth/convergence literature.

[10] In a recent study, Hummels and Klenow (2001) develop a measure for extensive (more varieties) versus intensive (more of the same varieties/goods) expansion. They relate these measures to country size to study how well the data capture the predictions of various variety models and to study the implications for the terms of trade of the various models. They find most support for Krugman-type models.

[11] In a recent paper, Chun and Nadiri (2002) attribute 30 percent of TFP to product innovation.

The paper is structured as follows. In the first section we derive the terms of trade equation for a world in which countries produce different sets of goods. We first present the estimation equation and we address some econometric issues related to the unobserved nature of the changing product quality and variety in the aggregate data. In section two we discuss the data that we use and also how we construct these. In the next section we focus on the empirical results, we study their robustness across various subsamples (rich vs. poor, big vs. small) and we show that the results do not change if we allow demand elasticities to vary across countries. We conclude in section four.

1. Setup

In this section, we provide a simple framework that should guide the empirical analysis. We consider a world economy in which each country produces a different (aggregate) good and in which countries import each other's goods. To differentiate goods by country of origin, we use the Armington (1969) assumption. This assumption is very helpful for two reasons. First, the assumption is consistent with international production specialization as obtained in many different trade models. Second, using the Armington assumption has an obvious empirical advantage. The assumption rationalizes the gravity equation (Anderson, 1979) that best describes existing trade patterns empirically and we use it in parts of the estimation.

Since the import quantities and price data that we use do not reveal the changing varieties and quality of a country's products, we first present the estimation equation for a given set of varieties in each country and with no change in the quality of the products that each country exports. In this setup, output expansion should negatively affect a country's terms of trade. In the section B, we investigate how the econometrician should address changing varieties and qualities that are not reflected in the price/output data that he/she uses and we build on the analysis of Feenstra (1994).

A. Theoretical Setup

Preferences are defined by a CES utility function for country *j* at time *t*.

(1) $U_{jt} = [\Sigma_i(\beta_i\, c_{ijt}^{(\sigma-1)/\sigma})]^{\sigma/(\sigma-1)}$

, where c_{ijt} is country j's consumption of the country i's (aggregate) good at time t. β_i reflects the taste for or the quality of the goods from i. σ is the elasticity of substitution between goods. (In the empirical implementation we also let σ vary by the size of the country of origin.) There could be many varieties produced in country i. In the present section we take the quality and the number of varieties in each country as given and assume for now, without loss of generality, that there is only one aggregate good in each country. Consumers in country j maximize utility subject to $\Sigma_i\, p_{ijt}\, c_{ijt} = y_{jt}$, which yields country j's demand for country i's products in equation (2). p_{ijt} is the price paid in country j for i's (export) good. We include iceberg transportation costs t_{ij}, so that $p_{ijt} = p_{it}\, t_{ij}\ (t_{ij} > 1)$. This latter addition to the model is critical since transportation costs are important determinants of trade flows. As we will relate transportation costs to distance in the empirical implementation, we will introduce geography into the analysis. Note that we will not explicitly study the effect of trade policy here, yet our estimates will control for changing trade policy.

(2) $c_{ijt} = \beta_i p_{it}^{-\sigma} t_{ij}^{-\sigma} y_{jt} / P_{jt}^{I\ 1-\sigma}$

, with $P_{jt}^{I} = [\Sigma_i\, \beta_i p_{it}^{1-\sigma} t_{ij}^{1-\sigma}]^{1/(1-\sigma)}$, the overall price index of country j.

After multiplying equation (2) by t_{ij} to account for the goods lost during shipment, we sum a country's effective demand over all countries j (*including* i). We obtain the effective, total world demand for the product of country i. In equilibrium this world demand equals world supply X_i, which under the Armington assumption amounts to country i's total production. After some rewriting, we obtain an expression for the price of county i's good, p_{it}, that is at the same time its export price, P_{it}^{X}.[12]

(3) $p_{it} = P_{it}^{X} = \beta_i^{1/\sigma} X_{it}^{-1/\sigma} [\Sigma_j\, t_{ij}^{1-\sigma} y_{jt} / (P_{jt}^{I})^{1-\sigma}]^{1/\sigma}$

Note that the last term in brackets in equation (3) is a country's market potential. Market potential captures the strength of demand for a country's product by measuring the size of the surrounding markets, discounted by how difficult it is to gain access to these. The latter is often

[12] We ignore that p_i is also part of P_j.

proxied for with bilateral distance.[13] We model a country's production with Cobb Douglas. A country's production depends on its total factor supplies and its productivity A_i that differs internationally. We consider the factors capital, labor and human capital. There is no international factor mobility.

(4) $X_{it} = A_{it} K_{it}^{\gamma 0} L_{it}^{\gamma 1} H_{it}^{\gamma 2}$ *with* $\Sigma_m \gamma^m = 1$

Moreover, we allow for international technology spillovers. In particular, total factor productivity A_{it} is taken to be a function of domestic R&D, $R\&D_{it}$, and foreign R&D, $FR\&D_{it}$, so that $A_{it} = \alpha_i \; Tech \; (R\&D_{it} \, , \, FR\&D_{it})$. There is a long tradition of production function estimation that relates total factor productivity to R&D, and that studies spillovers at the sectoral or international level, see Griliches (1995) and Nadiri (1993). Keller (2002a) surveys the literature on international technology diffusion. Foreign R&D can be transferred abroad through a multitude of channels. Trade (Coe and Helpman (1995)), FDI (Xu(2000)) or just any form of communication that allows for transfers of knowledge can be the vehicle of technology spillovers. We do not model one specific channel through which foreign R&D may affect a country's productivity.[14] Instead, we pursue an alternative strategy. In the empirical implementation, we relate foreign R&D to the bilateral distance between countries, which is likely to underlie many channels of technology transfer. This approach is supported by Keller (2002b) who provides evidence that the impact of foreign R&D on a country's productivity decreases with distance. Finally, note that α_i is allowed to differ across countries -- One reason could be because of institutional differences between countries, see Hall and Jones (1999).

The equations (3) and (4) describe for each good how the world equilibrium price is determined. Since we want to derive an index of a country's terms of trade, we transform the demand equation (3). For each good that country *i* imports, there exists such an equation. Define θ_{ki}^{M} as the fraction of *i*'s total (net) imports that is imported from country *k* -- Note that

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[13] Hanson (1999) has studied market potential at the regional level for the US; Redding and Venables (2001) do the same at the international level.

[14] As Keller (2002a) points out there is as of yet no model available that allows one to estimate the relative contribution of each channel.

we use k (and not j) to denote all countries (*except i*) from which i imports.[15] Next, raise, for each import good, the left and right-hand side of the price equation to the θ_{ki}^{M} th power. (Note that $\Sigma_k \theta_{ki}^{M} = 1$) After multiplying, for all import goods k, the left- and right-hand sides of the demand equations with each other, we obtain an expression for the index of the import prices of country i, P_i^M. (We suppress the subscripts of θ_{ki}^{M}.)

(5) $P_{it}^{M} = \Pi_k \, p_{kt}^{\theta M} = \Pi_k X_{kt}^{-1/\sigma\,\theta M} \, \Pi_k \, \beta_k^{\theta M} \, [\, \Sigma_j \, t_{kj}^{1-\sigma} \, y_{jt} \, /(P_{jt}^{I})^{\,1-\sigma}]^{1/\sigma\,\theta M}$

We finally obtain an expression for an index of country i's terms of trade, T_{it}, by dividing a country's export price by its import prices and by taking a logarithmic transformation.[16]

(6) $ln\,(P_{it}^{X}/P_{it}^{M}) = ln\,(T_{it}) = 1/\sigma \, ln\,(\beta_i \,/\Pi_k \, \beta_k^{\theta M}) \; - \; 1/\sigma \, ln\,(X_{it}\,/\Pi_k X_{kt}^{\;\theta M})$

$+1/\sigma \, ln\, RMP_{it}$

, where $RMP_{it} = \; [\Sigma_j \, t_{ij}^{1-\sigma} \, y_{jt} \,/\, (P_{jt}^{I})^{\,1-\sigma}]/\Pi_k [\, \Sigma_j \, t_{kj}^{1-\sigma} \, y_{jt} \,/\, (P_{jt}^{I})^{\,1-\sigma}]^{\,\theta M}$

Expression (6) is a relative demand equation that we want to estimate. The equation involves the demand for domestically produced export goods relative to the demand for foreign import goods. It characterizes the index of a country's terms of trade as determined by the preferences for the domestic versus the foreign goods, the amount of (gross) exported versus imported goods available and the relative market potential of the domestic versus the foreign goods, $RMP_{it.}$ Equation (6) can be viewed as one equation of a relative demand - relative supply system that determines the terms of trade. The figure below depicts a country's relative demand and supply schedule. With the elasticity of substitution, σ, positive and no change in the quality or varieties that countries produce, the relative demand equation (6) predicts that an increase in a country's own output relative to that of the rest of the world should, all else equal, worsen its terms of trade. An increase in a country's market potential with respect to the rest of the world should improve its terms of trade.

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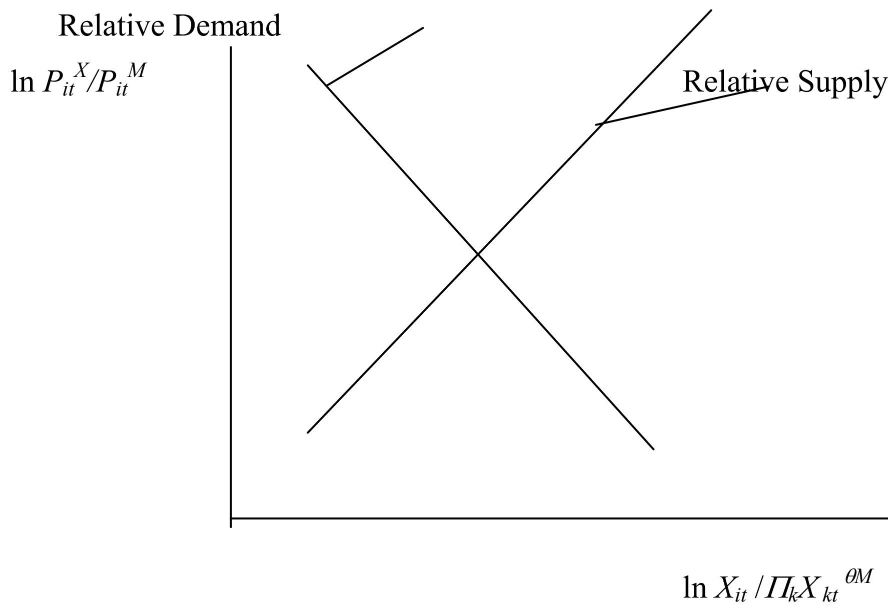
[15] To be explicit, the subscript '*j*' in '*ij*' stands for "all other countries (including *i*)" and '*k*' in' *ki*' for 'all other countries (excluding i)'. This distinction is important in equation (5) and (6).

[16] For notational convenience we treat the import prices free of transportation costs. We could rewrite equation (6) with transportation costs, using $p_{ij} = p_i t_{ij}$. This would result in a country-specific term in (6).



B Empirical Implementation and Econometric Issues

Our primary objective is to estimate the relative demand equation (6) as a single equation from a system of relative demand and supply. The estimation equation that we propose follows directly from the previous section.

(7) $\ln T_{it} = \vartheta_{0i} + \vartheta_1 \ln X_{it} / \Pi_{j\setminus i} X_{jt}^{\theta M} + \vartheta_2 \ln MP_{it} + \varepsilon_{it}$

The estimated coefficient ϑ_{0i} captures the relative preferences and the country fixed effects.[17] Based on the previous section, we expect a negative elasticity ϑ_1 for a country's output relative to that of the rest of the world and a positive ϑ_2 for a country's relative market potential. In the implementation we keep the import shares θM constant. This turns the terms of trade into a fixed base geometric price index and at the same time avoids endogeneity concerns, since constant shares are exogenous to whatever happens in any period other than the base year. This is simplification should not be much of a concern, given the relative stability of cross-country trade patterns. Moreover, the results will prove robust to changing the base year of the import

[17] Note that the data that we use price indices that are equal to 100 in the base year 1985, whereas the equations (4) an (7) are ratios of actual prices. The fixed effect in the estimation should take care of this difference. Indeed, if one subtracts from each side of equation (7) the log of the actual prices of 1985, which amounts to choosing 1985 as a base year, we can have price indices on the left hand side -- the actual prices of 1985 will simply be part of the fixed effect.

shares.[18] In the present section we discuss how we estimate our terms of trade equation. First, we discuss how (unobserved) changes in the quality and varieties of the goods that countries produce complicate the estimation. While doing so, we maintain the simplifying assumption that a country's endowments are exogenous. Next, we discuss how and to what extent a country's output can depend on prices (terms of trade) and any biases that one may expect.

If a country's endowments are exogenous, the proposed relative demand and supply setup is recursive and movements in the (vertical) supply curve should allow us to trace out the demand curve. Even though OLS yields in theory unbiased estimates in this case, we propose to instrument for output. The reason is fairly straightforward. When changes in our aggregate output measures are associated with (unobserved) changes in product quality and/or changes in the number of varieties, the error ε_{it} will be correlated with the regressors.

As in Feenstra (1994) we allow for two components in the error. There is random measurement error because our terms of trade data are based on unit values instead of actual prices. We also consider a more complicated source of error related to the export and import prices indices that we use to construct a country's terms of trade and that do not account for changing varieties or changing product quality within a country. Feenstra (1994) studies the implications of using such price indices and his analysis is directly relevant for our case. Feenstra generalizes for a CES function Diewert's exact price index for changing varieties/quality. He relates a conventional price index of a country's imports from another country i in period t, P_{it}, that does not account for changing varieties in i to the exact (unobserved) price index Π_{it} with changing varieties/qualities:[19]

(8) $P_{it} = \Pi_{it} (\lambda_{it-1} / \lambda_{it})^{1/(\sigma-1)}$,

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[18] To be explicit, this implies that terms of trade changes are primarily driven by the changing prices of goods and not by the shift in trading partners. Given the relative stability of trading partners, at least at the aggregate level, this should not be a major concern.

[19] In our setup, P_{it} corresponds to P_{it}^X in equation (3) -- a country's export price, or alternatively, the price of imports from that country (cleared of transportation cost that are constant).

where λ_{it} (λ_{it-1}) measures for the imports for country *i*, one minus the share of expenditures on the new (disappearing) product varieties. In other words, new (disappearing) products induce an upward (downward) bias in the conventional price index with respect to the exact price index. The intuition for this upward (downward) bias is fairly straightforward. New varieties were previously not available and therefore their price was high -- in theory infinite. A conventional price index that does not measure changing varieties will not account for any such price drops when new goods enter the market - i.e. they do not include the (unobserved) high price of the new variety before it entered the market. As argued by Krugman (1989) and in the terminology of Hummels and Klenow (2002), new goods are not just an increase of the intensive margin ("more of the same"), but they are also an increase in the extensive margin of goods. To sell these new goods, no actual price decrease is needed. Feenstra (1994) shows that when multiple varieties of a good are aggregated within a country (as in our case with Armington), any change in the number of varieties within a country is observationally equivalent to a change in the quality or preference parameter β_i for that country *i*'s goods, i.e.: $\beta_{it} = \beta_i (\lambda_{it-1} / \lambda_{it})$.

Applied to our terms of trade that are constructed with conventional price indices from individual exporting countries, the relative preferences $(\beta_i / \Pi_k \beta_k^{\theta M})$ in equation (7) should be adjusted by $[(\lambda_{it-1} / \lambda_{it}) / \Pi_k (\lambda_{kt-1} / \lambda_{kt})^{\theta x}]$. Since this change in the quality or varieties of a country's goods is not accounted for, it will be part of the error term. Therefore, the error in regression (7), in which preferences are assumed constant and part of the fixed effect, should be of the following form:

(9) $\varepsilon_{it} = 1/(\sigma-1) \ln[(\lambda_{it-1}/\lambda_{it}) / \Pi_k (\lambda_{kt-1}/\lambda_{kt})^{\theta x}] + z_{it},$

where z_{it} is i i d.

With the error in the terms of trade equation specified, one sees that there is bound to be a correlation between the error term (9) and the regressors in (7), when changes in an exporting country's aggregate output are associated with (unobserved) changes in the quality or the number of the varieties. We therefore propose a procedure in two steps to instrument for a country's output that should correct our aggregate output measure for changes in quality or varieties. To achieve this goal, we assume that product innovation is primarily a function of business R&D, which reflects the fact that esp. business R&D involves product development and improvement. (Note what is only required for our purposes is that a fixed fraction of business R&D in a country is spent on product development). It is also consistent with a large class of models à la Helpman and Grossman (1991).

In a first step, we run a fixed effect regression based on equation (4) that specifies how a country's total output is determined.

(10) $lnX_{it} = \alpha_i + \gamma_1 \ln Tech_{it} + \gamma_2 \ln K_{it} + \gamma_3 \ln L_{it} + \gamma_4 \ln H_{it} + \mu_{it}$

, where a country-specific effect α_i captures the (constant) differences in productivity across countries. $Tech_{it}$ measures changing technology in individual countries and is a function of domestic and foreign R&D. As in Keller (2002b) we relate the impact of foreign R&D on a country's productivity to the bilateral distance between countries. The advantage of this approach is twofold. On the one hand, as mentioned, it relates spillovers to an underlying determinant of many possible channels through which technology is diffused. On the other hand, introducing foreign R&D is a clever way of handling a practical problem. With foreign R&D we can account for technology in developing countries who typically have no (or very little, undocumented) R&D. We construct foreign R&D with bilateral distance weights as $F\&RD_{it} = \Sigma_j$ $(min\ distance_{ij}/distance_{ij})\ R\&D_{jt}$, where $min\ distance_{ij}$ is the minimal distance between any two country pairs[20]. Since esp. developing countries have no own R&D, we cannot separately estimate the impact of own vs. foreign R&D. Instead, we impute $Tech_{it}$ as $R\&D_{it} + FR\&D_{it}^{\ \phi}$, where ϕ $(0 < \phi < 1)$ measures the intensity of communication with other countries which is related to a country's relative size. For implementation we use a country's openness as measured by the ratio of its trade volume to its GDP in 1985 to proxy for ϕ.[21] The

[20] We obtain qualitatively similar results when we use for each country *i* the minimal distance with respect to its trading partners as opposed to the global minimal distance for the entire dataset. We experimented with the measure. Many variations are possible. Critical is that the foreign R&D declines with bilateral distance, that open countries have a stronger impact of foreign R&D.

[21] FR&D tends to be much bigger than own R&D. Weighting FR&D by ϕ $(0<\phi<1)$ therefore has the practical advantage (next to its conceptual relevance) that it avoid that the FR&D measure by its mere size wipes out any impact own R&D may have.

measures are quite reasonable. As expected, R&D is highest for developed countries because they are relatively close to one another, relatively open and in addition they have their own domestic R&D. The obtained estimates of this particular specification are in line with existing literature, see section 3b.

In a second step, we finally take the predicted output values minus A_{it} as instruments for country output.[22] In other words, we assume that the productivity increases that are induced by domestic R&D and by spillovers from foreign R&D are closely linked to changes in product variety or quality and they may therefore be correlated with the error term. This assumption is consistent with a wide class of models à la Grossman and Helpman (1991) in which product innovation and the range of products that a country produces is a function of the stock of R&D spending.[23] Also consistent with this assumption is the view that product innovation often brings about process innovation (new technologies/higher productivity).[24] As noted, our spillover regression (10) is part of a tradition of production function estimates, with Griliches (1995) as its most visible exponent, that proxies for technology A_i with R&D data. Such a specification has the advantage that it addresses, the best we can for aggregate data, concerns about the endogeneity of the production factors that would arise in any specification in which technological change would only be picked up in the error term.

As mentioned, if the endowments are truly exogenous, our proposed instrumental variables are adequate. One may be concerned, however, that prices (terms of trade) will affect a country's output, esp. through investment and capital accumulation. We know from the existing literature that explaining investment empirically is notoriously difficult. (Dixit and Pindyck, 1994, report

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[22] We also construct instrumental variables for output that are based on equation (10) without H_{it}, the human capital measure. The results turn out to be not significantly different from the estimates with H_{it}.

[23] Even though specification satisfies a fair number of theories, it does not cover all of them. Howitt (2000) for example relates quality changes also to capital accumulation.

[24] The empirical literature is far from disentangling product from process innovation. What little evidence there is, supports a view in which product innovation induces process innovation and not the other way around, Kraft (1990). Chun and Nadiri (2002) attribute some 30 percent of TFP growth in the computer industry to product innovation.

the mixed success to even relate investment to such primary explanatory variables as the interest rate.) In part, the poor empirical performance of the standard investment models has given way to adjustment cost models and more recently irreversible investment. Since investing is essentially based on expected future profitability, the irreversibility hypothesis expects the uncertainty of the future profitability of investment (because of changing regulations, changing input costs, fluctuating product prices, and uncertain success of new products,…) to matter significantly for current investment behavior. To the extent that the mean and the variance of a country's terms of trade help parametrize this uncertainty, our setup allows for these.[25] (If investment and capital are a function of the mean and variance of ε_{it}, both effects will be picked up by the country-specific fixed effect in regression (10) and taken out for the IV predicted value.) Note that allowing for mean variance effects is consistent with a body of work that links either the mean or the variance of a country's terms of trade to its savings behavior and hence to capital accumulation. Moreover, this literature is supported by growth regressions that show the significant impact of the average and the variance of the terms of trade on economic growth.[26]

Since we use the predicted output value purged of A_i as an instrument for output we cannot allow for any contemporaneous correlation between terms of trade and output through capital. To the extent that there is an irreversible component to investment, this contemporaneous correlation may be less of a concern. Should there, however, be any such correlation, then we know that the estimated coefficient will be biased. In this case, the question arises whether we can still be confident that the sign of the estimated coefficient is the right one. If our terms of trade regression had relative output as the only independent variable, it could easily be shown that the estimate of ϑ_l will be upward biased (because improving terms of trade spur investment and capital accumulation). While this simple intuition does not carry over in general to a multivariate regression, it does prove relevant for our baseline regression with two

[25] See Pindyck and Solimano, 1993.

[26] See for example Mendoza (1996)

dependent variables. Here also we expect an upward bias in ϑ_1.[27] From this perspective it is important to note that we will estimate a negative ϑ_1, suggesting that ϑ_1 in absolute values may be a lower bound estimate and that any correction for the bias should preserve the estimated sign.

Now consider how we measure the relative market potential term, RMP_i. We propose to derive the relative market potential from a gravity equation of country i's (real, effective) exports to country j and we use equation (2), after premultiplying it by t_{ij}, for that purpose.[28] Specifically, we run the log of real, effective exports on a dummy for the exporting country η_i (to capture $ln\beta_i p_{it}^{-\sigma}$), a dummy for the importing country χ_j (for the log of country j's real income) and the distance between the countries involved (to get at $1\text{-}\sigma\, ln\, t_{ij}$). This procedure is analogous to Redding and Venables (2003) and, as we explain below, of particular interest here. Note that the gravity regression should also include domestic consumption in country i, c_{ii}, since we focus on the equilibrium of total world demand and supply -- We use a measure of internal distance to proxy for distance in this case. We add an extra dummy for domestic consumption, χ_{ij} that is one if $i = j$ and zero otherwise to capture the importance of borders that has recently received a fair amount of attention, see McCallum (1995). The proposed regression in year t is:[29]

(11) $lnt_{ij}c_{ij} = \alpha + \eta_i + \chi_j + \gamma\, ln\ distance_{ij} + \chi_{ij} + \xi_j$

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[27] Levinsohn and Petrin (2003) discuss the potential bias due to a correlation between the independent variables and the error term for a two-variable regression. Take the regression $y_{it} = \vartheta_0 + \vartheta_x x_{it} + \vartheta_z z_{it} + \varepsilon_{it}$, where y stands for the terms of trade, x for relative output and z for relative market potential. The OLS estimates for the independent variables will be: $\hat{\vartheta}_x = \vartheta_x + [(\boldsymbol{\sigma}_{z,z}\, \boldsymbol{\sigma}_{x,\varepsilon} - \boldsymbol{\sigma}_{x,z}\, \boldsymbol{\sigma}_{z,\varepsilon})/ (\boldsymbol{\sigma}_{x,x}\boldsymbol{\sigma}_{z,z} - \boldsymbol{\sigma}^2_{x,z})]$ and $\hat{\vartheta}_z = \vartheta_x + [(\boldsymbol{\sigma}_{x\,x}\ \boldsymbol{\sigma}_{z,\varepsilon} - \boldsymbol{\sigma}_{x,z}\, \boldsymbol{\sigma}_{z,\varepsilon})/ (\boldsymbol{\sigma}_{x,x}\boldsymbol{\sigma}_{z,z} - \boldsymbol{\sigma}^2_{x,z})]$.
(Bold faced $\boldsymbol{\sigma}_{a,b}$ denotes the sample covariance between a and b, $\hat{\vartheta}$ the estimate of the true parameters ϑ.) By the Cauchy-Schwarz inequality we know that the denominator of the bracketed term is always positive, so that its sign depends on the numerator. If , as we fear, indeed x is correlated with ε ($\boldsymbol{\sigma}_{x,\varepsilon}>0$) and z is not ($\boldsymbol{\sigma}_{z,\varepsilon}=0$), there will be an upward bias in $\hat{\vartheta}_x$. Moreover, as Levinsohn and Petrin (2003) point out, even if in addition z were correlated with ε, it is the case that as long as the correlation between relative output x and ε is stronger than between z and ε there will be an upward bias in $\hat{\vartheta}_x$ (and a downward bias in $\hat{\vartheta}_x$). Moreover, to the extent that we (see later) manage to proxy for *ε (the changing varieties/qualities)* adequately with relative per capita GDP or relative R&D expenditure stocks in the regressions with more than two variables, we should be less concerned about the impact of the bias.

[28] I thank Feenstra and Hanson for this suggestion.

[29] For ease of implementation we ran regression (11) for each year separately. (Since we measure relative market potential, differences in constant terms across regressions are irrelevant.) Note that

With the estimates of regression (11) we construct country *i*'s relative market potential for each year as follows

(12) $RMP_i = \{\Sigma_j \exp(\chi_j + \gamma \ln distance_{ij} + \chi_{ij})\} / \Pi_k \{\Sigma_j \exp(\chi_j + \gamma \ln distance_{kj} + \chi_{kj})\}^{\theta M}$

Note why the relative market potential measure is attractive in the present context. Any change in varieties or quality will be captured by a different η_i each year and the estimated real income of the importing country is conditional on this change.[30] In addition, since we run a different regression each year, γ should also control for any changes in trade policy. To avoid concerns about the endogeneity of RMP_i, we also use a measure of market potential that excludes country i, χ_{ij}.[31]

2. The Data Requirements

A. Terms of trade

To construct an index of a country's terms of trade we rely on price indices from the World Bank's World Tables (1991) which is one of the few terms of trade data sets that cover a wide number of countries for an extended period of time on an annual basis. This dataset has been the source for Mendoza (1996), Acemoglu and Ventura (2001) and Baxter and Kouparitsas (2000). Baxter and Kouparitsas (2000) discuss the features of the dataset in detail and slice the data in many different ways. The World Tables provides for over one hundred countries' export price and import price between 1970 and 1988 (The collection of data was terminated in 1991). Because the dataset is relatively short, it is not meaningful to study the time series characteristics of the terms of trade on a per country basis. We have to turn to panel regression unit root tests. Our data reject Breitung and Meyer's (1994) unit root test (for common AR lag, with (and without) trend, and with per country fixed effect). While this finding does not preclude the existence of unit roots in individual countries, it does suggest that for the dataset

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[30] Since we do not include a non-linear measure for the intensity of the quality preferences, as in Hallak (2002), our changing varieties/quality are appropriately captured in a year effects.

[31] This is similar to Hanson (1998) and Redding and Venables (2001) who study market potential empirically at the regional level and at the international level.

as a whole unit roots are not pervasive (We use 3, 4 or 5 lagged differences).[32] Note finally that all the price indices are based on dollar denominated unit value calculations from disaggregate data.

We use three different measures of the terms of trade to ensure the robustness of our results. First, we directly take the ratio of the overall export and import price from the World Tables. The disadvantage of this measure is that it also reflects changing prices of trade with third countries -- countries that are not part of the 51 countries for which we also have output and endowment data. (Table 1 provides the complete list of countries.) This may esp. be a concern since our 51 countries include only few oil-exporting countries. Second, to address this disadvantage we construct another terms of trade index that is consistent with the set of countries that we use in our dataset. Like Baxter and Kouparitsas (2000), we construct for each country an aggregate import price P_{it}^{M} with countries export prices. We combine the export prices of the other 50 countries from which a country imports with the shares of these countries in total imports to construct a fixed-base geometric-means price index. We hold the import shares fixed for 1985, which is the base year of all our variables in which by definition real and nominal shares are the same.

(15) $P_{it}^{M} = \Pi_k P_{kt}^{\theta M}$

, where θ^{M}_{kj} is the fraction of country *i*'s imports that come from country *k* in the base year.

Finally, we substitute the 1985 weights in the price index for the real import shares of 1975. The three measures are highly correlated: the correlation between the overall terms of trade and the 1985 and 1975 weighted terms of trade is respectively 88 and 89 percent. The correlation between the 1975 share and the 1985 share data is 99 percent. Figure 1 illustrates how the

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[32] For reference: In a pooled regression of the terms of trade on its lag, the coefficient of the lagged terms of trade is 0.8, significantly less than 1. When allowing for country specific fixed effects the coefficient is 0.7 and with country-specific trends 0.68. Following Dickey and Fuller the unit root hypothesis can be tested by performing the following regression $\Delta y_{it} = \mu_i + \beta_t + \delta y_{i,t-1} + \alpha_1 \Delta y_{i,t-1} + \ldots + \alpha_p \Delta y_{i,t-p} + u_{it}$ (The null hypothesis is that $\delta=0$) (estimated) Using the best estimator under the null, (the estimated) $\mu_i = y_{i1}$, Breitung and Meyer (1994) obtain the resulting test regression $\Delta y_{it} = \beta_t + \delta(y_{i,t-1} - yit1) + \alpha_1 \Delta y_{i,t-1} + \ldots + \alpha_p \Delta y_{i,t-p} + v_{it.}$ An OLS regression yields an asymptotically normally distributed t-statistic. With 4 lags, $\delta = 0.04$ (s.e. 0.01, t=3.2) and statistically different from 0 at the 95 percent level, with 5 lags, $\delta = 0.033$ (s.e. 0.01, t=2.9), again statistically different from 0 at the 95 percent level.

terms of trade (with 1985 weights) evolve for three developed and three developing countries. We discuss the data sources of the bilateral trade shares under B.

B. Trade shares

Trade shares enter the analysis in two ways. We need bilateral trade shares to construct our price indices and our relative output measures. We extract the bilateral import shares of our 51 countries from Feenstra et al. (1997). We take a set of shares for 1985, which is the base year of all our indices and real values, and a second set for 1975 to check whether the results are sensitive to the year we choose. Table 2 provides the shares for 1985. (When calculating 1975 shares we deflate trade flows with the export and import price indices from the World Bank.)

C. Bilateral distance

To construct the relative market potential measures, we need to run a gravity equation on dummies and bilateral distance. We take the distance measures from Robertson's website (http://www.macalester.edu/%7ERobertson). Since we also want to account for country size, we consider countries circles and take the radius of a country's surface to proxy for its internal distance. Country surfaces are taken from the *CIA Factbook*. One finds these internal distance measures in Table 3.

D. Factor supplies, Technology and Output Predictions

To instrument for output, we need to run the fixed effect output regression (10) which requires aggregate output and R&D data plus data of factor inputs. We use the factor supplies of Harrigan (1997) from the Penn World Tables. We aggregate durable goods and nonresidential capital from the Penn World Tables. We base our human capital measure on the four categories of schooling from Barro and Lee (1993) -- we take the ratio of the sum of the two categories of people with the highest education to the two lowest ones. The aggregate output data for 51 countries are taken from the Penn World Tables in PPP values. Table 1 discusses the data sources in detail.

In the implementation we relate a country's productivity to its R&D. Coe and Helpman (1995) constructed business R&D stocks, for 21 OECD countries. With these R&D stocks we construct our own distance-weighted foreign R&D measures as $F\&RD_{it} = \Sigma_j$ *(min distance$_{ij}$/distance $_{ij}$).*[33] We use Coe and Helpman's stocks of own (business) R&D expenditures for the OECD and construct for all 51 countries $Tech_{it}$ as $R\&D_{it} + FR\&D_{it}\,^{\phi}$. Since we only have (own) R&D data for the OECD, we implicitly assume that countries outside the OECD do not have own R&D. This is in line with the observation that the bulk of R&D takes place in the OECD countries and with the hypothesis that technology spillovers outside the OECD should be critical for technological change in these countries. For ϕ (between zero and one) we take the openness measure (export+imports)/(2xGDP) from the Penn World Tables. Note that openness captures very well the extent to which a country may depend on other countries (openness is negatively correlated with country size, so that smaller countries are bound to have more interactions with foreign countries).

The predicted values of a country's real output are obtained from the following fixed effect production regression (after subtracting A_{it}). We suppress the coefficients of the 51 country specific effects.

$$(8) \quad lnX_{it} = 5.7 + \alpha_i + 0.12\, Tech_{it} + 0.29 ln\, K_{it} + 0.56\, lnL_{1it} + 0.09 lnH_{it} + \mu_{it}$$
$$(t,10.5) \quad (t, 6.5) \quad (t,11.6) \quad (t,10) \quad (t,4.7)$$

n: 918 overall R^2: 94 (with dummies: 99)

We explain a large fraction of the variation and the estimated coefficients are in line with the expectations -- slightly less than a third for the capital share, about 60 percent for labor. The elasticity for R&D is around 0.12, which is fairly reasonable. Griliches (1995) reports an elasticity between six and ten percent from R&D on firm-level productivity. At a higher level of aggregation, however, one expects a higher estimate since there can be spillovers external to the firm.

E. Relative Market Potential

[33] Coe and Helpman (1995) used a trade-weighted FR&D measure and were criticized for it in Keller (1998) and Coe and Hoffmaister (1999).

We construct the relative market potential measures as suggested by equation (12) and the work of Hanson (2002) and Redding and Venables (2003). For each year, we run a separate gravity regression, using the export data for our group of 51 countries and the relevant time period from the standard Feenstra et. al. (1997) CD-rom. For internal consumption we take real GDP from the Penn World Tables adjusted for trade flows. The gravity regression also includes the distance measures that we discussed under C. Figure 2 plots relative market potential against country size for the year1980.

4. Estimation Results

As the estimates from Table 4 illustrate, there is qualitative support for the terms of trade equation (7). The first three columns of Table 4 show the fixed effect equation in its most stripped-down version. We present estimates with three different terms of trade measures -- all equations are estimated with the robust Huber/White estimator, yielding consistent standard errors in the absence of homoskedastic error. In the first column we use the fixed base geometric terms of trade index that we constructed with the 1985 bilateral trade shares of the 51 countries that we study. In the second column we choose the World Bank overall terms of trade measures that do not restrict the trading partners to our 51 countries. In the third column we substitute the 1985 shares of the first index for the (real) 1975 bilateral shares.

We obtain similar results with the different terms of trade measures. An increase in a country's output with respect to the output of its trading partners has a negative impact on a country's terms of trade. It should be noted that the output changes that we consider are primarily driven by factor accumulation and correct for any impact of foreign and domestic R&D on output. The assumption is that domestic R&D and spillovers from foreign R&D are likely to be correlated with changing varieties and product qualities and hence with the error term.[34] Moreover, as

[34] To correct the output predictions for any impact of R&D turns out to matter. In particular, without any IV's for output, we obtain for the stripped-down version, the following (inconsistent) results that differ from the results mentioned so far:

$$\ln T_{it} = \vartheta_{0i} + \underset{(0.16)}{0.009} \ln X_{it} / \Pi_{j \setminus i} X_{jt}^{\theta M} + \underset{(3.4)}{0.046} \ln MP_{it} + \varepsilon_{it}$$

R2: 0.017, n:918

argued, the sign of the estimated relative output coefficient is robust to any upward bias that could arise if a country's total output would positively depend on its (contemporaneous) price (i.e. an upward sloping supply curve). If anything, correcting for the bias would make the coefficient more negative.[35] Therefore, the obtained estimate is a lower bound. Our results also confirm the prediction that an increase in a country's relative market potential raises the price of a country's export good versus its import good, which amounts to an improvement of its terms of trade. Finally, note that the Hausman test clearly rejected the random effect model in favor of the fixed effect regression that is consistent with the setup.

As indicated by equation (9), a change in the varieties or the quality of the goods that are being produced will make the error non-random. In particular, the error term varies with changing product quality and variety. By construction, our instrumental variables should be orthogonal to the error term and the output increase that we measure (without any impact of R&D) should be uncorrelated with changing variety/quality. Still, the fact remains that quality and variety changes are a determining factor of a country's terms of trade as we measure them. We therefore choose a proxy for changing varieties/qualities in our regression. In the recent empirical micro literature a higher per capita GDP is found to be strongly correlated with higher quality goods (see, Hallak, 2002, Schott, 2002) and so is an increase in the varieties of goods (see, Funke and Ruhwedel, 2001, Hummels and Klenow, 2002). We include a measure of countries' relative per capita GDP in the regression, i.e. $relgdp_{it}=ln[(X_{it}/L_{it})/ \Pi_k (X_{it}/L_{it})^{\theta M}]$. $relgdp_{it}$ should proxy for the nonrandom component in the error of (9) and capture the change in quality/variety of the exported vs. the imported goods.

As expected, we find a positive and significant coefficient on relative per capita GDP in columns 4-6 for our three different terms of trade measures. This suggests that the increasing quality/variety of a country's goods with respect to the rest of the world induces an improvement in the terms of trade as measured by a conventional price index. An increase in

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As noted, the coefficient on relative output has the wrong sign and is insignificant.

[35] For a more extensive discussion of our ability to sign the bias when we have two regressors, see section B and footnote 25.

the quality and variety of a country's output represents an outward shift in the relative (world) demand for its products. We also construct a second measure that is based on the literature, in which R&D is associated with changing varieties/quality. We take each country's productivity measure A_{it} from our production equation (10) and weight it with the respective trade share, i.e. $relprod_{it} = ln(A_{it}/ \Pi_k A_{it}^{\theta M})$. As the estimates in columns 4 to 6 in the Table in the Appendix indicate, the coefficients are similar in sign and magnitude, yet a little less precisely estimated. (The productivity measure is significant at the 90 percent level for two terms of trade measures.) Note that including also an alternative, less precise relative market potential measure (without country *i*'s output) generates no major differences. The signs and magnitudes of the coefficients are similar (for one terms of trade measure, the relative output measure is only significant at the 90 percent level.)

The obtained estimation results are of particular interest. They suggest that rapidly expanding countries can avoid dramatically decreasing terms of trade, to the extent that their rapid growth is associated with product quality or variety upgrading. Alternatively, it suggests that secularly declining terms of trade will occur only in countries that do not manage to improve the quality and variety of their products and whose per capita GDP/total factor productivity steadily worsens with respect to the rest of the world. This is, if you will, a more realistic version of the Prebisch-Singer prediction.

As the results in Table 4 reveal, we only explain 2 to 8 percent of the within-country variation when estimating equation (7), which is relatively low. (With dummy variables the R^2 is 43 and 44 percent.)[36] This relatively low explanatory power is probably due to the prices that need time to adjust to changing output and demand conditions. Similar as in Harrigan (1997), we therefore introduce the lagged dependent variable in the regression. Note that the total impact of, say, relative output on the terms of trade amounts to $\vartheta_1(1/(1-\nu)$ with a lagged dependent variable in the regression -- ν is the estimated coefficient on the lagged variable. Including the lagged terms of trade increases the explanatory power of the regression significantly. It reaches 50 percent or more (with dummies over 70 percent). It is heartening to note that the sign and

[36] Explicitly including the country dummies explains about 43 percent of the variation.

significance of the coefficients on a country's relative output, its market potential and the proxy for changing varieties/quality do not change as we introduce the lagged variable. Moreover, including the lagged specification makes the coefficients across the various terms of trade regressions more similar in magnitude.[37]

Introducing a lagged dependent variable as an explanatory variable raises additional concerns, however. Amemiya (1967) has pointed out the favorable asymptotic properties as $T \rightarrow \infty$ for our fixed effect least square estimator. In this case the fixed effect least squares estimator is consistent and equivalent with Maximum Likelihood. As Hsiao (1986) argues, however, a problem arises in shorter periods in which all variables, including the lagged dependent variable, are demeaned to eliminate the unknown fixed effect. In this case one should be concerned about a downward bias in the estimated coefficient of the lagged dependent variable. With a relatively long panel of 18 years this is probably not a major issue. And indeed, it turns out that the downward bias is only minimal. We use the Arellano-Bond GMM estimator that avoids the downward bias on the lagged dependent variable by differencing out the fixed effects and by estimating the terms of trade equation with instrumental variables (including higher-order lags of the dependent variable). As the estimates for the three different terms of trade measures show in columns 7 to 9 of the appendix, the estimated coefficient of the lagged dependent variable are virtually identical. (The difference ranges from 0.02 to 0.04.) The other coefficients have the same sign and are similar in size. Since the A-Bond estimator is much less efficient that the fixed effect estimator (with robust error correction), however, the relative market potential variable is no longer significant at the 90 percent level.

One may wonder how robust our obtained results are and to what extent they control for the oil crises. A few things should be mentioned in this respect. First, since the vast majority of the countries in our sample are non-oil producing/exporting countries, dropping the oil exporters from the sample does not make a significant difference, see column 1 to 3 in Table 5. Second, we use different price indexes in the empirical exercise. Our main terms of trade index is constructed with the import/export prices of the 51 (mostly non-oil producing) countries and

[37] Note that with our data we reject the null of a unit root in a dynamic panel. For a discussion of the time series properties of the terms of trade, see data section

will only be affected by oil prices to the extent that they filter through in the prices of their own products. Note, however, that our findings are robust to using the overall terms of trade of a country that explicitly include oil imports. Finally, to the extent that most of the countries in the sample are oil-importers, the oil crises can be perceived as a common shock. We therefore explicitly include year effects for 1973-1974 and 1979-1980, which does not affect the estimates.

Next, we study the estimates across different subsamples. We refer to the columns 7 to 12 in Table 5 and the estimates in Table 6. We split the dataset between small and big countries and between developed and developing countries. (Each time we divide the dataset in two equal parts after ranking countries according to respectively total GDP or per capita GDP). We first split the sample in big and small countries. Overall, all coefficients have the same sign and are similar in magnitude. (The coefficient on market potential is only significant at the 90 percent level for bigger countries in two of the three cases.) We also divide the sample in developing and developed countries see Table 6. The results for developing countries are strongest. For developed countries all signs are same, yet some variables are no longer significant.)

It is often expected that smaller countries have a smaller impact on prices and hence on their terms of trade than bigger countries.[38] One can rightly remark that the presented estimates so far do not establish the individual impact of countries on their own terms of trade and for that matter do not show whether bigger or smaller countries have a stronger impact on the terms of trade. We have been using a *relative* output measure up till now. The negative coefficient could therefore, at least in theory, entirely reflect output changes in the rest of the world and mask the fact that an individual country does not have an independent impact on its own terms of trade. We next decompose relative output in a country's own output ("World Output of the Export good" in Table 4) versus the output of its trading partners ("World Output of the Import goods" in Table 4). Only for the bigger countries do find evidence that a country has an impact on the terms of trade. The estimates in columns 7-9 show a negative (and significant) coefficient on a

[38] This goes beyond the theoretical specification with its perfectly symmetric setup and the Armington home-bias assumption for all countries.

country's own output and a positive (sometimes insignificant) coefficient on the output of the other countries for the bigger countries. (The coefficients are insignificant and of the wrong sign for the smaller countries, not reported.)

Finally, we relax the assumptions of the setup a little more. In particular, in the setup we assume that the elasticity of substitution between goods (the inverse of the estimated coefficients) is the same across countries. Bigger countries are often expected to face a less elastic demand and to have more of an impact on the price of their goods. We try to address this concern to some extent. Because of how we set up the estimation equation (i.e. by weighing the import prices by countries' import shares) we implicitly corrected for the relative size of countries at the import size. We did not correct, however, for the size of the exporting countries themselves. We let the coefficients vary with country size in two ways. We rank countries according to country size, and group them into small, medium size and big countries of equal size. We give each country the number of the group is part of (G_c):1 for small, 2 for medium size and 3 for big. We then impose that $\vartheta_i = \vartheta_i G_c$. As reported in the columns 1 to 3 of Table 7 the estimates remain significant. Another option is to directly use for G_c the log of each individual country's GDP in 1985. The obtained results are similar.

Conclusion

The terms of trade is a core concept in international economics. From the classical economist till the Prebisch-Singer hypothesis, movements of terms of trade, their impact and their causes have been intensely debated. Also in the more recent trade and wages debate do terms of trade play a prominent role, as researches have tried to link the growing wage inequality to changing relative prices and in particular to the ever increasing, cheaper imports from developing countries. Despite this active interest in the subject, the attempts to explain a country's terms of trade with fundamental real determinants such as factor accumulation, productivity, etc. are scarce. Often terms of trade are conveniently assumed to be exogenous in the empirical literature and countries are said to have no impact on their own terms of trade.

In this paper, we analyze the determinants of countries' terms of trade empirically. In a stylized setup with geography on both the supply (through technology spillovers) and the demand side (through market potential), we establish that increases in a country's output relative to the rest of the world due to factor accumulation have a negative impact on its terms of trade. On the other hand, we find that an increase in a country's relative market potential means more demand for a country's products and hence an increase in its terms of trade.

Our evidence also suggests that countries have a way of averting terms of trade decreases. Fast output expansion does not have to lead to worsening terms of trade when it is accompanied by increases in a country's relative per capita GDP or by R&D induced productivity increases. Since per capita GDP is strongly correlated with increasing varieties/quality and since variety and quality upgrading is related to R&D in a wide class of models and to TFP in (some) empirical work, our results confirm Krugman's (1989) claim that quality/variety upgrading should not have a negative impact on a country's terms of trade. Indeed, output expansion that takes the form of newer and better products will coincide with an outward shift of the world demand for a country's products. This finding casts a new light on the Prebisch-Singer hypothesis. Secularly declining terms of trade should only be expected in countries that consistently fail to innovate and upgrade the quality and varieties of their output.

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Figure 1
Terms of Trade, by countries

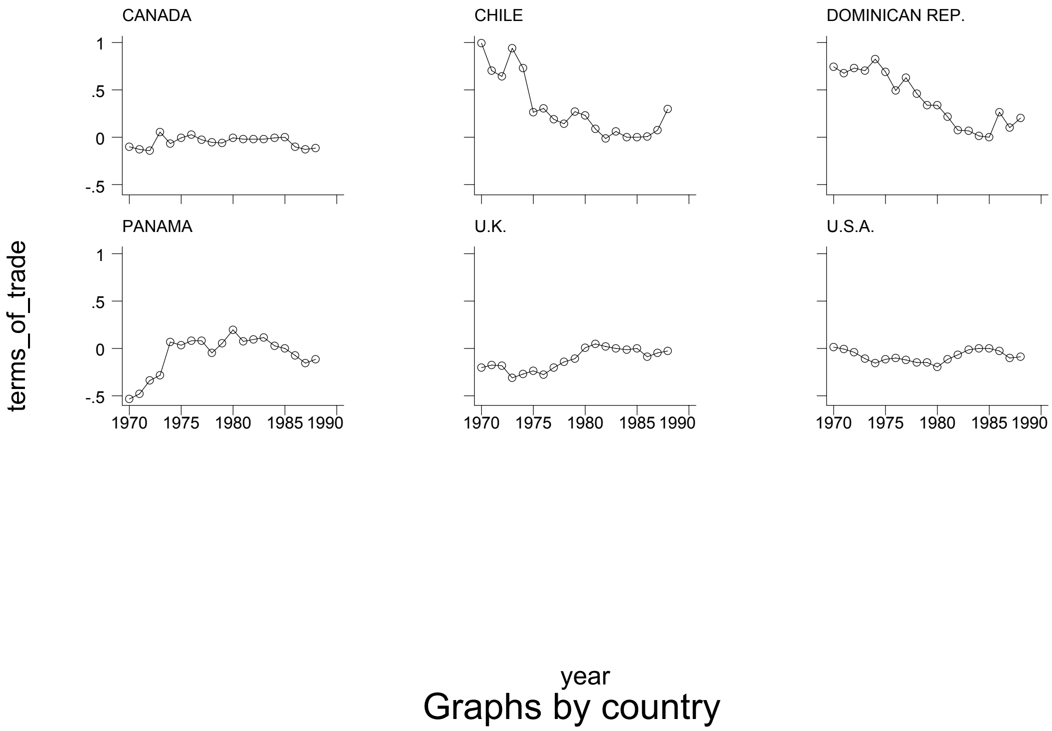


Figure 2
Relative Market Potential vs. Output (1980)

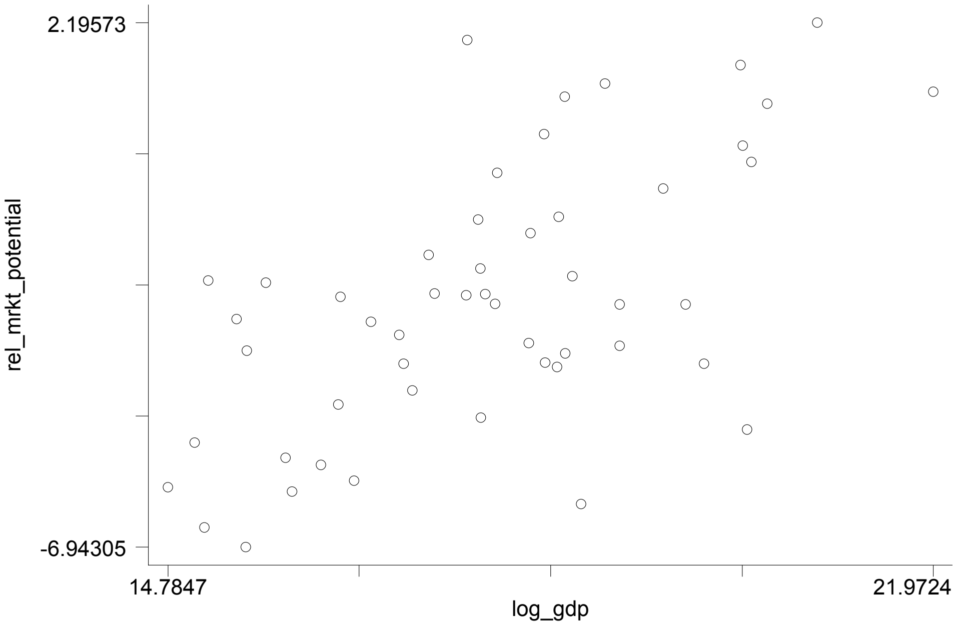
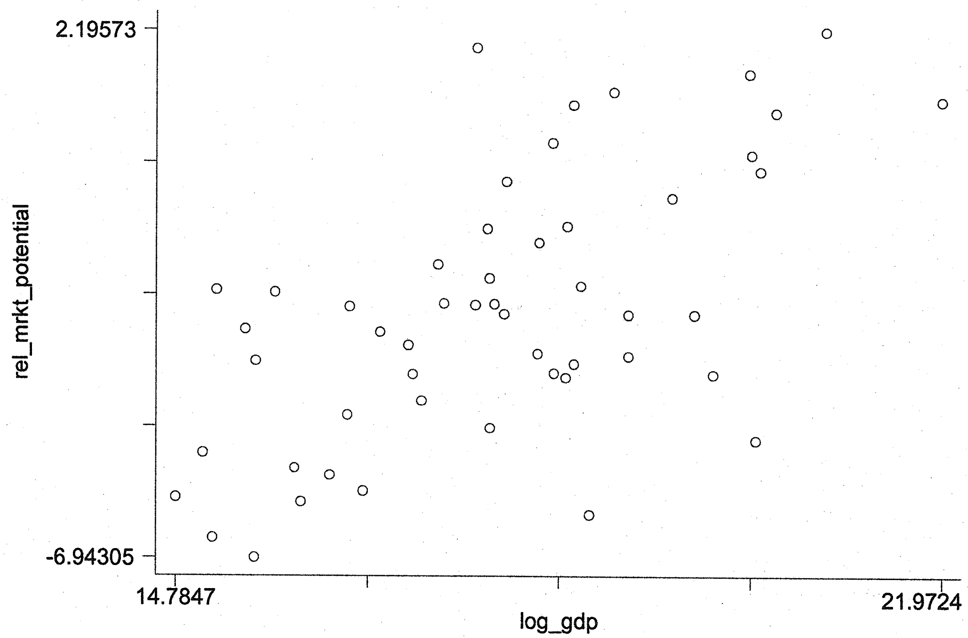


Table 1
Endowment, R&D and Production Data

Years:	1970 - 1988
Countries:	Argentina, Australia, Austria, Belgium, Bolivia, Canada, Chile, Colombia, Denmark, Dominican RP, Ecuador, Finland, France, Germany, Greece, Guatemala, Honduras, Hong Kong, Iceland, India, Ireland, Israel, Italy, Jamaica, Japan, Kenya, Korea RP, Malawi, Mauritius, Mexico, Nepal, Netherlands, New Zealand, Norway, Panama, Paraguay, Peru, Philippines, Portugal, Sierra Leone, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Turkey, United Kingdom, USA, Venezuela, Zambia, Zimbabwe (51 countries)
Real GDP:	Real GDP: Penn-World Tables 5.6 (PWT 5.6)
Capital:	PWT 5.6 Sum of (1) durable goods capital, and (2) nonresidential construction capital
R&D Stocks:	Coe & Helpman (1995) R&D stocks for 21 OECD countries.
Labor:	PWT 5.6 Total Population
Human Capital:	Barro and Lee (1993) Ratio of population with at least secondary education over population with at most primary education.
Distance:	Bilateral distance between capital cities (kilometers), from Jon Haveman's website (http://www.macalester.edu/research/economics/PAGE/HAVEMAN)
Internal Distance:	CIA, The World Factbook 2001 (www.cia.gov/cia/publications/factbook/index.html)

Figure 2
Relative Market Potential vs. Output (1980)



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Internal Distance:	CIA, The World Factbook 2001 (www.cia.gov/cia/publications/factbook/index.html)

Table 3
Internal Distance

Country name	Internal Distance	Country name	Internal Distance
ARGENTINA	938	KOREA RP	177
AUSTRALIA	1564	MALAWI	194
AUSTRIA	163	MAURITIUS	24
BELGIUM	99	MEXICO	792
BOLIVIA	591	NEPAL	212
CANADA	1782	NETHERLANDS	115
CHILE	491	NEW ZEALAND	292
COLOMBIA	602	NORWAY	321
DENMARK	117	PANAMA	158
DOMINICAN RP	125	PARAGUAY	360
ECUADOR	300	PERU	640
FINLAND	328	PHILIPPINES	309
FRANCE	417	PORTUGAL	171
GERMANY	337	SIERRA LEONE	151
GREECE	205	SPAIN	401
GUATEMALA	186	SRI LANKA	145
HONDURAS	189	SWEDEN	378
HONG KONG	19	SWITZERLAND	115
ICELAND	181	THAILAND	404
INDIA	1023	TURKEY	498
IRELAND	150	UNITED KINGDOM	279
ISRAEL	81	USA	1751
ITALY	310	VENEZUELA	539
JAMAICA	59	ZAMBIA	489
JAPAN	347	ZIMBABWE	112
KENYA	431		

Source: CIA, The World Factbook 2001

Table 4

Estimates of terms of trade regression (7): with and without lagged terms of trade

	Dependent variable: Terms of Trade								
	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Output of Export vs Import goods	-0.07	-0.23	-0.09	-0.12	-0.33	-0.15	-0.08	-0.11	-0.09
	(-2.1)	(-6.0)	(-2.6)	(-3.0)	(-7.0)	(-3.6)	(-2.5)	(-2.6)	(-2.3)
Relative Market Potential	0.05	0.05	0.06	0.06	0.05	0.06	0.02	0.02	0.02
	(4.0)	(3.4)	(5.0)	(4.5)	(4.0)	(3.2)	(2.3)	(2.3)	(2.5)
Relative per Capita Income				0.52	0.83	0.58	0.38	0.36	0.37
				(2.9)	(4.0)	(3.2)	(3.0)	(2.6)	(2.9)
Lag Terms of Trade							0.69	0.71	0.69
							(11.0)	(14.0)	(11.0)
R2	0.02	0.05	0.03	0.04	0.08	0.05	0.56	0.6	0.57
Observations	918	918	918	918	918	918	867	867	867
Robustness	yes	Yes	yes	yes	yes	yes	yes	Yes	yes
Fixed effect	yes	Yes	yes	yes	yes	yes	yes	Yes	yes

Notes:

(1) t-statistics in parentheses.

Table 5

Accounting for oil crises and small vs big countries

	Dependent variable: Terms of Trade											
	Non-Oil Exporters			Oil dummy			Small			Big		
	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Output of Export vs Import goods	-0.08 (-2.4)	-0.1 (-2.7)	-0.08 (-2.5)	-0.05 (-1.8)	-0.1 (-2.6)	-0.06 (-1.8)	-0.11 (-2.1)	-0.13 (-2.1)	-0.11 (-2.0)	-0.05 (-1.9)	-0.12 (-2.1)	-0.08 (-2.1)
Relative Market Potential	0.02 (2.0)	0.02 (2.0)	0.02 (2.3)	0.02 (2.2)	0.02 (2.4)	0.02 (2.5)	0.02 (1.9)	0.02 (1.5)	0.02 (2.3)	0.02 (1.4)	0.4 (2.3)	0.02 (1.5)
Relative per Capita Income	0.36 (3.0)	0.33 (2.5)	0.35 (2.9)	0.3 (2.5)	0.33 (2.5)	0.29 (2.4)	0.33 (2.2)	0.33 (1.9)	0.31 (2.0)	0.52 (2.7)	0.48 (2.2)	0.54 (2.8)
Lag Terms of Trade	0.69 (13.0)	0.71 (18.0)	0.69 (14.0)	0.69 (11.0)	0.69 (12.7)	0.69 (11.4)	0.67 (10.5)	0.69 (12.0)	0.68 (11.0)	0.71 (6.0)	0.72 (9.5)	0.71 (6.1)
R2	0.54	0.6	0.55	0.57	0.61	0.59	0.55	0.59	0.56	0.58	0.63	0.58
Observations	833	833	833	867	867	867	425	425	425	442	442	442
Robustness	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Fixed effect	yes	Yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Oil dummy				yes	yes	yes						

Notes: (1) Critreria for small-big, GDP.

(2) t-statistics in parentheses.

Table 6

Rich vs Poor countries and a country's own-output effect

	Dependent variable: Terms of Trade								
	Poor			Rich			Big		
	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Output of Export vs Import goods	-0.11 (-2.6)	-0.13 (-2.4)	-0.12 (-2.7)	-0.04 (-1.0)	-0.09 (-1.6)	-0.04 (-1.0)			
Relative Market Potential	0.02 (2.2)	0.02 (2.2)	0.03 (2.5)	0.01 (1.0)	0.01 (0.9)	0.01 (0.9)	0.02 (1.6)	0.04 (2.4)	0.02 (1.7)
Relative per Capita Income	0.38 (2.5)	0.35 (2.1)	0.37 (2.4)	0.46 (2.5)	0.44 (1.9)	0.46 (2.5)	0.44 (2.4)	0.4 (1.9)	0.46 (2.5)
Lag Terms of Trade	0.68 (11.0)	0.7 (13.0)	0.67 (11.0)	0.7 (5.7)	0.71 (8.1)	0.71 (5.7)	0.71 (6.0)	0.71 (8.0)	0.71 (6.0)
World Output of Export goods							-0.06 (-1.7)	-0.1 (-2.1)	-0.07 (-1.9)
World Output of Import goods							0.03 (1.0)	0.07 (1.5)	0.04 (1.0)
R2	0.54	0.61	0.56	0.59	0.6	0.59	0.58	0.63	0.58
Observations	425	425	425	442	442	442	442	442	442
Robustness	yes	Yes	yes	yes	yes	yes	yes	yes	yes
Fixed effect	yes	Yes	yes	yes	yes	yes	yes	yes	yes

Notes: (1) Critreria for rich-poor, GDP per capita.
(2) t-statistics in parentheses.

Table 7

Adjusting coefficients for country size

	Dependent variable: Terms of Trade					
	Size ranking			Log of Size		
	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75
	(1)	(2)	(3)	(4)	(5)	(6)
Output of Export vs Import goods	-0.04 (-2.7)	-0.05 (-2.9)	-0.04 (-2.8)	-0.008 (-2.6)	-0.01 (-2.7)	-0.009 (-2.6)
Relative Market Potential	0.01 (2.4)	0.01 (2.7)	0.01 (2.6)	0.002 (2.4)	0.003 (2.6)	0.003 (2.6)
Relative per Capita Income	0.17 (3.2)	0.16 (2.8)	0.16 (3.1)	0.04 (3.1)	0.04 (2.6)	0.04 (3.0)
Lag Terms of Trade	0.69 (11.0)	0.71 (14.0)	0.7 (11.0)	0.69 (11.0)	0.7 (14.0)	0.7 (11.0)
R2	0.56	0.61	0.57	0.56	0.61	0.57
Observations	867	867	867	867	867	867
Robustness	yes	Yes	yes	yes	yes	yes
Fixed effect	yes	Yes	yes	yes	yes	yes

Notes:

(1) t-statistics in parentheses.

Table Appendix: Robustness

	Dependent variable: Terms of Trade								
	Alternative Market Portential*			Alternative Technology**			Arellano and Bond		
	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75	TOT 85	TOT WB	TOT 75
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Output of Export vs	-0.06	-0.25	-0.08	-0.06	-0.21	-0.07	-0.08	-0.17	-0.07
Import goods	(-1.5)	(-5.2)	(-1.9)	(-1.7)	(-5.2)	(-2.0)	(-1.9)	(-3.3)	(-1.5)
Relative Market	0.03	0.03	0.03	0.05	0.05	0.06	0.01	0.01	0.01
Potential	(6.0)	(6.3)	(6.2)	(4.0)	(3.4)	(5.0)	(0.8)	(0.5)	(0.3)
Relative per	0.35	0.65	0.39	0.49	0.68	0.65	0.53	0.51	0.51
Capita Income	(2.0)	(3.1)	(2.2)	(1.7)	(1.8)	(5.0)	(1.7)	(1.4)	(3.7)
Lag Terms of Trade							0.73	0.73	0.73
							(34.0)	(35.0)	(37.0)
R2	0.04	0.1	0.05	0.03	0.06	0.04			
Observations	918	918	918	918	918	918	816	816	816
Robustness	yes	yes	yes	yes	yes	yes	yes	yes	yes
Fixed effect	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes:

(1) t-statistics in parentheses.
(2) * excluding the domestic market demand.
(3) ** relative productivity instead of relative per capita GDP.