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ORIGINAL ARTICLE

Land Abundance, Openness, and Industrialization

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Abstract
With a modified formalization of Heckscher–Ohlin theory as the basis of a novel econometric specification, this paper uses worldwide data over three decades to estimate how the effects of greater openness on industrialization vary among countries with differing endowments of land relative to labour. The results confirm the theoretical prediction that greater openness reduces manufactured output shares in land-abundant countries, while increasing them in land-scarce countries. The implications of these results for trade and development policy are debatable.

JEL codes: F11; F16; F63; O14

Keywords: Heckscher–Ohlin; trade and development; deindustrialization; resource curse

1. Introduction

A long history of concern (since List, 1841) that greater openness to trade in poorer countries may hinder them from catching up with richer countries intersects with concern (e.g., Sachs and Warner, 1995) that development may be slowed by natural resource abundance. Matsuyama (1992) shows theoretically how openness could reduce growth in resource-abundant countries by causing them to do less manufacturing. Casual observation also suggests that, during the boom in world trade after 1980, successful development was concentrated on export-oriented countries with few natural resources.

There has been much econometric work on each of these concerns separately (on openness and development surveyed by Winters, 2004 and Harrison and Rodriguez-Clare, 2010, on resources and development surveyed by Smith, 2015 and Venables, 2016), but little on their intersection. This paper's contribution is thus to estimate how the interaction between a country's openness and its resources affects the relative sizes of its manufacturing and primary sectors, using data for 1985, 2000, and 2014 that cover almost all of the world.

Sectoral size is measured by share in GDP, and openness by a synthetic index of the height of trade policy barriers. Total land area – though rarely used – provides an unbiased, exogenous, and statistically powerful measure of a country's natural resources, from which the land–labour ratio is derived by dividing by its adult population. The – apparently novel – specification of the regressions relates the manufactured–primary GDP ratio to the land–labour ratio, openness, and the interaction between them, using a range of methods of estimation.

The theoretically expected negative coefficient on the openness–land–labour ratio interaction is of similar size when estimated across countries and within countries. It is robust to alternative specifications and to the addition of controls, as well as being substantial. For a country of average size and average schooling with a high (top decile) land–labour ratio, manufacturing's share of the value of goods output (primary plus manufactured) would be 11 percentage points lower

with a trade policy at the top decile rather than the bottom decile of openness, compared to 18 points higher for a country with a bottom decile land–labour ratio.

From a policy perspective, the implications of these results are debatable. Interaction between land abundance and openness does not appear to have amplified cross-country differences in levels of income. During 1985–2014, however, income growth was inversely related to land abundance, and more strongly so in countries that adopted more open policies. It would now be hard to offset the comparative disadvantage of land-abundant developing countries in manufacturing by sectoral protection, as earlier in some land-abundant developed countries. It also seems doubtful that land-abundant countries could pursue an alternative development path in services, which share with manufacturing much lower land intensity than primary production. Trade and development policies probably should differ between land-scarce and land-abundant countries, but mainly in their intra-sectoral and cross-sectoral specifics.

From an academic perspective, this paper contributes an extra dimension to the application of Heckscher–Ohlin (HO) theory. Many studies have sought to estimate the effects of variation in factor endowments on sectoral structure – usually the structure of trade (e.g., Leamer, 1984; Wood and Berge, 1997; Chor, 2010), but in a few cases, as in this paper, the structure of output (e.g., Harrigan, 1997; Schott, 2003; Wood, 2003; Blum, 2010). Those that have used appropriate specifications have confirmed that factor endowments strongly influence sectoral structure (as illustrated in the worldwide map in Figure A1 of the online Appendix).

None of the output structure studies, though, has investigated how the effects of endowments vary with the height of barriers to trade. Their results refer implicitly to outcomes at the average degree of openness of the countries in their data. However, in this paper's modified HO model, which draws on that of Rotunno and Wood (2020), the elasticity of output structure with respect to endowments increases with a country's openness to trade.

The reason is that larger foreign-firm shares of home markets and larger home-firm shares of foreign markets cause demand for a country's outputs to depend more on the higher elasticities of substitution between home and foreign varieties and less on the lower substitution elasticities among goods. Derived demand for factors becomes more elastic, so relative factor prices respond less to variation in endowments. The share of an endowment change that is absorbed by intra-sectoral factor-price-induced changes in technique is thus smaller, and the effect of the endowment change on relative sectoral outputs larger, than in a less open country.

This paper offers reduced-form estimates of the effect of openness on the relationship between output structure and factor endowments. Structural estimation of the causal links underlying this effect would require more information on land rents and land use than is available for the range of countries and years covered in this study. Indirect evidence of the links, however, can be derived from the results of Rotunno and Wood (2020), who estimate a similar model, with a different pair of factors, both in reduced form and structurally. They find that, with greater openness to trade, factor prices are less affected by variation in endowments.

As mentioned, the paper adds also to two other bodies of econometric work. First, it contributes to the trade and development literature by interacting an openness measure with endowments (not done in any of the 175 studies reviewed in Harrison and Rodriguez-Clare, 2010). Second, it contributes to the 'resource curse' literature (Smith, 2015) by interacting a broad measure of natural resource abundance with a measure of openness to trade, which can be seen as a generalization of studies of the 'Dutch disease' effects of high-value mineral exports.

In addition, this paper's results contribute to the literature on 'premature deindustrialization', which Rodrik (2016) argues to be a widespread feature of recent development. Haraguchi et al. (2017), by contrast, show that developing countries in aggregate have not deindustrialized. These two seemingly conflicting views are actually consistent, because during the globalization of 1985–2014 manufactured output shares fell in land-abundant developing countries, while rising in (a smaller number of larger) land-scarce developing countries.

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Section 2 outlines the modified version of HO theory. Section 3 presents the empirical strategy, data, and results, and Section 4 concludes.

2. Theory: Heckscher and Ohlin Reconsidered

Heckscher–Ohlin (HO) theory is of obvious relevance in analysing how the effects of trade on industrialization differ among countries of differing land abundance. Because manufacturing production requires less land relative to labour than primary production, the theory implies that greater openness in countries with above world average endowments of land relative to labour will (over the medium term, and with balanced trade) reduce manufactured output relative to primary sector output. To estimate this relationship, however, requires some modifications to the Heckscher–Ohlin–Samuelson (HOS) formalization of HO theory, which are outlined in this section, with supporting algebra in Smith and Wood (2023).

In the HOS model of a small trading country with two goods and two factors, the causes of variation in the structure of output can be summarized in the notation of Jones (1965) by

$$\hat{q}_M - \hat{q}_A = \frac{1}{(\lambda_{NM} - \lambda_{LM})}(\hat{v}_N - \hat{v}_L) + \sigma\left[\frac{1}{(\lambda_{NM} - \lambda_{LM})(\theta_{NM} - \theta_{NA})} - 1\right](\hat{p}_M - \hat{p}_A) \quad (1)$$

where q_M and q_A are the outputs of manufactures and primary products, v_N and v_L are supplies of land and labour, and p_M and p_A are the prices of manufactures and primary products (world prices adjusted for trade costs), all expressed in small proportional changes ($\hat{x} = dx/x$). θ_{ij} is the share of factor i in the cost of good j, with the greater land intensity of primary production implying that $(\theta_{NM} - \theta_{NA})$ is negative, λ_{ij} is the share of the supply of factor i used by good j, again with $(\lambda_{NM} - \lambda_{LM})$ negative, and σ is the elasticity of substitution in production between land and labour, assumed for simplicity to be the same within both sectors.

The first right-hand-side (rhs) term specifies the elasticity of the manufactured–primary output ratio with respect to the land–labour ratio. Because manufacturing is less land-intensive than primary production, maintaining full employment of land and labour after a rise in the land–labour ratio requires a fall in the manufactured–primary output ratio. This fall in the output ratio is 'magnified' – i.e., proportionally greater than the change in the land–labour ratio – though less so, the larger is the difference in land intensity between the sectors.

The second rhs term, if world prices are fixed, determines the elasticity of the manufactured–primary output ratio with respect to the height of barriers to trade in manufactures relative to barriers to trade in primary products. For example, increasing tariffs on manufactured imports raises the relative output of manufactures by raising the relative price of manufactures, which raises the wage of labour relative to the rent of land. This change in relative factor prices induces firms to switch to techniques using less labour and more land, reducing the relative supply of land and requiring a higher manufactured–primary output ratio to keep both factors fully employed.

Equation (1) neatly describes some causal relationships that are highly relevant to the present paper, but appears to provide no basis for the empirical analysis it proposes to undertake. The manufactured-output-reducing effect of greater land abundance in its first term is not increased by greater openness, and the effect on relative output of changes in relative trade barriers in its second term does not depend on the land–labour ratio. The equation thus looks inconsistent with the HO intuition – which will be seen to be empirically well-supported – that a country's manufactured–primary output ratio depends on the interaction between its land–labour ratio and its openness. To incorporate this interaction into the equation requires some rethinking of both its terms.

To generate an interaction in the second term, all that is needed is to recognize that variation in the relative height of barriers to trade in manufactures and primary products typically reflects variation both in countries' openness (defined as the average height of their barriers to trade across all goods) and in the levels of their land–labour ratios relative to the world average.

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In HO theory, greater openness tends to reduce the amounts that trade barriers add to the prices of imports of goods in which endowments create a comparative disadvantage (and/or to raise the prices received from exports of comparative-advantage goods). So, for example, increases in openness in land-abundant countries usually reduce tariffs mainly on manufactures, but in land-scarce countries mainly on primary products.[1] Extended in this way, the second term of (1) can be labelled the 'endowment-conditioned output-openness elasticity'.

The required modifications to the first term of equation (1) are more substantive. As written, it assumes that in countries that trade internationally – as all do, to some extent – goods prices and factor prices are fixed by world prices, including the costs created by trade barriers. More recent theory, however, recognizes that even for individual countries demand and supply in world markets are less than infinitely elastic. One widely accepted explanation of this inelasticity is qualitative differences – and thus imperfect substitutability – among varieties of the same good produced by different countries (Armington, 1969) or different firms (Krugman, 1979). Another widely accepted explanation is differences in efficiency and location among countries (Eaton and Kortum, 2002) and among firms (Melitz, 2003).

With finite demand elasticities, absorbing a change in the land–labour ratio by a change in the manufactured–primary output ratio requires relative goods prices to change in the opposite direction. In competitive markets, this change in relative goods prices also alters relative factor prices, making the factor whose relative supply has increased relatively cheaper and thus inducing changes in techniques in both sectors to use relatively more of it. This change in techniques absorbs part of the change in the land–labour ratio, which reduces the size of the change in the manufactured–primary output ratio that is needed to clear factor markets. The output–endowment elasticity is therefore smaller than in the first term of equation (1).

What creates an interaction in this term is that the effective size of the finite demand elasticities is likely to rise with a country's openness to trade (Rotunno and Wood, 2020). Where lower barriers to imports cause home firms to have smaller shares of the home market, the prices they charge for their varieties have a smaller effect on the average prices of all varieties of the goods concerned, so the relative sales of home varieties of different goods depend more on the higher elasticities of substitution in consumption between foreign and domestic varieties and less on the lower elasticities of substitution among goods. Moreover, lower barriers to exports increase the share of the output of home firms sold in foreign markets, of which they usually have small shares and where their sales depend mainly on the high elasticities of substitution between their varieties and those of their foreign competitors.

For these reasons, the more open a country is to trade – the lower its barriers to importing and exporting – the more do its endowments tend to affect its output structure. In autarky, where the relative prices of goods (and of factors) are governed by domestic supply and demand, only the low elasticity of substitution in consumption between manufactures and primary products would matter, minimizing the response of output structure to changes in the land–labour ratio. By contrast, in a country where trade barriers were so low that home firms had only tiny shares of the home market and sold only tiny shares of their output in the home market, only the high elasticities of substitution between foreign and domestic varieties would matter, maximizing the response of output structure to changes in the land–labour ratio. The modified first term of equation (1) can thus be labelled the 'openness-conditioned output-endowment elasticity'.

Greater openness could affect the output-endowment elasticity in other ways, too, not all in the same direction. More use of imported intermediate inputs would cause changes in a country's relative factor costs to have less effect on the relative prices of its varieties of different goods,

[1]A rise in openness would thus usually make $\hat{p}_M - \hat{p}_A$ in equation (1) negative in a land-abundant country and positive in a land-scarce country. However, for lack of a good way of formalizing theoretically the endowment-conditioned relationship between changes in openness and in relative sectoral trade costs, section 4.2 of Smith and Wood (2023) analyses only the effect of changes in relative sectoral trade costs on output structure.

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reducing the elasticity. Imported input use also widens the gap in local factor intensity between manufacturing and primary sectors, though with an ambiguous effect on the elasticity.[2] Greater openness might reduce the output-endowment elasticity, moreover, by raising the intra-sectoral elasticity of substitution between factors, which depends on induced changes in intra-sectoral product mix as well as in choice of techniques (Schott, 2003). The greater influence of higher elasticities of substitution among varieties, for example, might cause a higher land–labour ratio to raise the relative output of more land-intensive goods within both sectors, and so lessen the relative fall in aggregate manufactured output. On balance, however, greater openness seems likely in theory to increase the output-endowment elasticity.

In summary, modification of the HOS equation (1) exposes two interactions between the effects of the land–labour ratio and of openness to trade on a country's relative output of manufactured and primary products. One is the openness-conditioned output-endowment elasticity, obtained by extending the first term of (1) to include imperfect substitutability between the varieties of goods made in different countries, which causes relative sectoral outputs to be more responsive to changes in relative endowments in countries that are more open. The other interaction is the endowment-conditioned output-openness elasticity, obtained by extending the second term of equation (1) to include changes in openness (defined as the average height of trade barriers), the direction of whose effect on relative barriers to trade in (and hence relative output of) manufactures and primary products usually depends on whether the land–labour ratio of the country concerned is above or below the world average land–labour ratio.

Estimation needs to allow for other theoretical influences on the manufactured–primary output ratio. Manufacturing and primary production differ not only in land-intensity but also in human capital intensity, so that the manufactured–primary output ratio will vary also with the education of a country's labour force. These two sectors may differ in non-human capital intensity, too, but with less effect on manufactured–primary output ratios because of the international mobility of financial capital. Non-HO theory suggests that, because of external economies of scale in manufacturing, the manufactured–primary output ratio will depend on country size, and also suggests that this output ratio may vary because of non-price influences on domestic demand and uneven access to production technologies.

3. Evidence: The Openness-Endowment Interaction

This section, summarizing a more detailed discussion in the online Appendix, explains the specification and data used for reduced-form estimation of the modified HOS model, and presents the results. The theoretical linkages discussed above are approximated by a regression of the form

$$\ln r_{M/A} = \zeta_0 + \zeta_1 \ln v_{N/L} + \zeta_2 o \times \ln v_{N/L} + \zeta_3 o + \mu \tag{2}$$

in which $r_{M/A}$ is the ratio of manufactured to primary output, $v_{N/L}$ is the ratio of land to labour supplies, and o is an index of openness to trade, with these last two variables – crucially – being interacted as well as appearing separately. The regression also includes controls for schooling and country size, and it is estimated with data for 125 countries (containing 99% of the world's population) in 1985, 2000, and 2014.

The dependent variable – the manufactured–primary output ratio – is based on sectoral shares of GDP from the UN National Accounts database, with primary being agriculture, forestry, and fishing, plus mining. These GDP shares are unavoidably measured at current national prices, and denoted in equation (2) by r for revenue, rather than q for quantity as in equation (1), with implications for the interpretation of the results that will be discussed below.

[2]The wider gap, due to replacing locally supplied intermediate inputs by cheaper or better imported ones, tends to reduce the elasticity, because a given change in endowments can be absorbed by a smaller change in relative output, but also to increase it, because the change in relative goods prices caused by endowment-induced changes in output has less effect on relative factor prices, so less of an endowment change is absorbed intra-sectorally.

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A country's land–labour ratio is measured by its total land area divided by its adult population, using data from World Development Indicators. Total land area is an uncommon measure of natural resources, but it is potentially relevant to all types of primary products, and it has greater explanatory power than alternative measures (the correlation coefficient across countries between ln $r_{M/A}$ and ln $v_{N/L}$ is −0.47). It is also an unbiased measure, because what a country has, per square kilometre of its surface area, in terms of soil fertility, water resources, minerals, and so on, can be seen as the outcome of a random draw, and it avoids the endogeneity of more specific measures of natural resources.

Openness to trade is derived from the 'de jure trade globalization' index of Gygli et al. (2018), on a 0-1 scale, with higher values meaning more openness. This index averages the prevalence of non-tariff barriers, compliance costs of trade, revenue from taxes on trade, and the mean tariff rate. To allow for policy barriers to trade abroad as well as at home, the openness index for each country is calculated as its own index value multiplied by a weighted average of the values of the index in its potential trading partners.

The validity of the estimates obtained with equation (2) depends on its right-hand-side variables being exogenous. For land and adult population, exogeneity is a good assumption. A country's land area is determined by its geography and history and there no reason to expect a direct causal effect of output structure on birth and death rates.

The openness index is potentially endogenous, but does not seem to be strongly influenced by the manufactured–primary output ratio. Granger causality tests on the sub-periods 1985–2000 and 2000–2014 yield negligible correlations, with the exception of an R-squared of 0.44 between the 1985–2000 change in the openness index and the 1985 level of the manufactured–primary output ratio. A plausible reason for this higher correlation was the widespread advocacy of 'export-oriented industrialization', motivated by the East Asian 'miracles' (World Bank, 1993). This advocacy led many countries with substantial manufacturing sectors to adopt more open trade policies, and can reasonably be regarded as an exogenous shock.

A country's trade policy index – its chosen degree of openness – could also be influenced by its factor endowments, as a result of political action by potential gainers and losers from trade. Endogeneity of this sort, however, does not bias estimates of the effect on the manufactured–primary output ratio of variation in the policy index and in endowments, though it affects the global pattern of the output ratio relative to the global pattern of endowments.

A country's manufactured–primary output ratio could be influenced by many things beyond the scope of the theory in section 2 and the variables and controls in equation (2), whose omission could bias the estimated coefficients on the included variables. Reducing this problem by using country fixed effects is complicated by lack of variation over time in land areas, so the analysis makes use also of two non-standard methods of estimation.

One is average cross-section (AVCS), in which equation (2) is estimated with the 1985–2014 mean values of variables. In the other method (labelled LVCH), the 1985–2014 change in the manufactured–primary output ratio is regressed on the 1985–2014 change in the openness index, the 1985–2014 average level of the land–labour ratio, and the interaction between the change in the policy index and the level of the land-labour ratio.

Table 1 shows the results of estimating equation (2) by four different methods: pooled ordinary least squares (POLS) with year fixed effects for 1985 and 2000, average cross-section (AVCS), fixed effects (FE) for both years and countries, and the levels-changes (LVCH) approach described above. Summary statistics and a correlation matrix are in Tables A5 and A6, and robustness checks in section A.4, of the online Appendix.

The most important results for this paper, which would be much the same without the country size and schooling controls, are the coefficients on the interaction between the openness policy index and the land–labour ratio. As expected from the modified HO model in section 2, all of these coefficients are negative: greater openness to trade tends to increase the adverse effect of a higher land–labour ratio on the manufactured–primary output ratio.

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Table 1. Manufactured–primary output ratio regressed on endowments and openness

	POLS	AVCS	FE	LVCH
Log of square kilometres of land per adult	0.03	0.04		−0.13
	(0.07)	(0.12)		(0.06)**
(Log land per adult) × (Openness policy index)	−0.64	−0.68	−0.65	−0.59
	(0.17)***	(0.31)**	(0.18)***	(0.31)*
Openness policy index	1.51	1.68	0.20	0.27
	(0.40)***	(0.67)**	(0.52)	(0.45)
R-squared	0.61	0.67	0.93	0.27
Number of observations	369	123	369	123

Notes. Regressions include controls for country size and schooling (Table A1). The dependent variable is (level or change of) logged ratio of manufactured to primary (agriculture + mining) GDP. POLS = pooled ordinary least squares (year fixed effects for 1985 and 2000). AVCS = average cross-section (using means of 1985, 2000, and 2014 values). FE = fixed effects for years and countries, with the land–labour ratio omitted because of perfect collinearity with the country size variable. LVCH = 1985–2014 changes in output ratio and policy index, but average level of land per adult. The openness policy index combines own value with potential partner values. Robust standard errors in parentheses: statistical significance * (10%), ** (5%), *** (1%).
Sources. GDP from UN National Accounts Main Aggregates data. Land area and population from World Development Indicators. Openness policy index from Gygli et al. (2018).

Across all methods of estimation, moreover, these coefficients are of about the same size: −0.6. The conditioning influence of greater openness on the effect of variation in land abundance on the manufactured–primary output ratio thus appears similar, whether it is estimated in levels (AVCS), in changes (FE), or in a mixture of levels and changes (POLS and LVCH). All four coefficients, moreover, are statistically significant, though none is precisely estimated.[3]

The coefficients on the land–labour ratio in the first row refer, because of the interaction term, to the effect on the manufactured–primary output ratio of variation in land abundance at a zero value of the openness policy variable. The levels (AVCS) estimate of this coefficient therefore refers to hypothetical countries that are almost closed to trade, and its near-zero value implies that differences in their land–labour ratios would have little effect on their manufactured–primary output ratios.

This result may seem inconsistent with theory: even in a closed economy, a higher land–labour ratio should reduce the manufactured–primary output ratio (Smith and Wood, 2023). But output is measured here in terms of value, so a reduction in the output quantity ratio tends to be offset by a rise in the price ratio. Indeed, a zero coefficient is just what theory would predict in a closed economy if the elasticity of substitution in consumption between manufactures and primary products was unity (as often assumed in models with the sort of two-tier utility function used to analyse the effects of openness on output elasticities in Smith and Wood, 2023).

The land–labour cell in the FE column is blank. Constant land areas cause perfect correlation between changes in the land–labour ratio and in country size (measured by adult population), so one of them must be omitted from the FE regression. Neither of them has much effect on the results, as evidenced by the similarity between the AVCS and POLS land–labour and size coefficients. Nor does either of them on its own have an economically sensible FE coefficient, because of a misleading negative correlation between changes in population and in the output ratio.[4] So,

[3]The FE and POLS estimates, which involve 1985–2000 and 2000–2014 changes, would become less precise if their standard errors were clustered across years. The LVCH estimate involves only 1985–2014 changes.

[4]The correlation is misleading because it is likely to reflect omitted variables, particularly institutional or political influences on development, which through various channels affect both birth rates and the costs of establishing and operating manufacturing firms.

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since omitting the size variable would have resulted in a nonsense land–labour ratio FE coefficient of 0.24, it seemed better to omit the land–labour ratio.

In the LVCH specification, the coefficient on the land–labour ratio is negative. Its sign (unlike that of an FE estimate) is not saying anything about the effect of changes over time in the land–labour ratio, whose level is held constant. What it says is that in hypothetical countries whose openness policy indices did not change during 1985–2014, manufactured–primary output ratios fell in land-abundant countries relative to land-scarce countries. A plausible explanation is the big transfer of labour-intensive manufacturing technology through outsourcing by developed-country firms to land-scarce low-wage developing countries whose policies were already open enough (or who improved their infrastructure enough) to make this transfer profitable.

The coefficients in the policy index row of Table 1 suggest that more openness might benefit manufacturing even in land-abundant countries (of given size and schooling). For instance, because the demand for manufactures is income-elastic, a rise in income from primary exports could increase the relative demand for domestically produced manufactures, or manufacturing might benefit more than primary production from better access to world-class intermediate inputs. The way the interaction term is estimated, with means subtracted from the land–labour and schooling variables, causes the policy index coefficient to measure the effect on the output ratio of a unit rise in the index in a country of world-average land abundance and schooling. In a pure HO model, this effect should be zero, but all the coefficients are positive.

The POLS and AVCS coefficients are implausibly large, implying a five-fold rise in the output ratio, almost certainly because they are picking up the effects of omitted variables. Countries with more open policies may also have other policies or institutions that raise their per capita incomes or help the supply of manufactures more than of primary products, such as better legal, regulatory, or internal transport systems. The coefficients in the FE and LVCH columns are of a more believable size. They imply that moving from autarky to free trade would increase the manufactured–primary output ratio of a country with average factor endowments by about one-quarter – though in reality this would require not only changes in trade policies but also much investment in trade-related infrastructure.

The economic significance of the estimated land-openness interaction is assessed in Table 2 by using the regression results to predict the relative sizes of manufactured and primary output for hypothetical countries with differing land–labour ratios and openness to trade, though all of median schooling and size. Predicted output ratios are converted into more easily understood shares of manufacturing in goods (manufactured plus primary) output.

The predictions use coefficients mainly from the AVCS regression, in which the key openness-land interaction coefficient is close to that in all the other methods of estimation, and whose near-zero land–labour coefficient, almost identical to its POLS counterpart, was argued earlier to be explicable theoretically by the use of output value rather that output quantity data.[5] The openness index coefficient that is used in the predictions, however, is derived from the FE and LVCH regressions and is far lower than the AVCS coefficient.

In the top row, which refers to the least land-abundant countries, the manufacturing share is 18 percentage points higher in the most open countries than in the least open ones. For the most land-abundant countries in the bottom row, by contrast, this share is 11 points lower in the most open than in the least open countries. At the upper and lower quartiles of the land–labour ratio, the corresponding numbers are 12 points higher and 4 points lower. The slight rise across the median land–labour ratio row reflects the relative benefit of more openness to manufacturing in all countries, regardless of their land abundance.

The predicted shares in Table 2 refer to output values. If they could be calculated instead with data for relative output quantities, the variation of shares within each column would be greater,

[5]In the absence of a FE land–labour coefficient, for reasons explained earlier, the alternative would have been the −0.13 LVCH land–labour coefficient, which seemed less appropriate because it is estimated from a mixture of variation in land–labour ratio levels with variation in output and openness changes.

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Table 2. Predicted sectoral structure at different land abundance and openness quantiles: manufacturing's share of manufactured plus primary output (%)

	Openness to trade					
Land/labour ratio	D1 (least)	Q1	Median	Q3	D9 (most)	D9–D1
D1 (lowest)	43	45	48	55	61	18
Q1	42	43	45	50	54	12
Median	40	40	41	42	43	3
Q3	38	38	37	36	34	−4
D9 (highest)	36	35	32	29	25	−11
D9 minus D1	−7	−11	−16	−27	−36	−30

Notes. D refers to deciles, Q to quartiles. Predictions use coefficients from AVCS regression in Table 1, except policy index coefficient reduced to match FE and LVCH estimates, offset by an increase in the constant term. Median levels of country size and years of schooling.

because land–labour ratio changes are supply-side shocks that push relative prices and relative quantities in opposite directions, though less so in columns further to the right, because greater openness to trade raises demand elasticities. Calculations in section A.6 of the online Appendix suggest a big effect: in the least-open column, quantity data would quadruple the gap in manufactured output shares between the least and most land-abundant countries, and in the most-open column would make this gap 1.5 times greater than in Table 2.

Conversely, the variation in output quantity shares across rows would be smaller than in Table 2, because increased openness to trade is a demand-side shock that pushes relative prices and relative quantities in the same direction. However, the calculations in section A.6 suggest that the effect of using quantity data would be small: a difference of about one-tenth. For example, the rise across the most-land-scarce row of Table 2 would be 16.5 percentage points for the quantity share, rather than 18 points for the value share, while the decline in the share across the most land-abundant row would be 10 percentage points, rather than 11 points.

4. Conclusions

The motivation of this paper was concern that greater openness to trade may slow development in land-abundant countries. The concern has two causal links: first, that greater openness may cause such countries to specialize in primary production, pulling labour, skill, and capital away from manufacturing; and second, that manufacturing may have more potential for growth than primary production.

The paper has focused on the first causal link and in particular on trying to establish empirically both its existence and its size. This required some modifications to the standard HO model, in which the usual concept of openness is not an explicit variable and in which the effect of factor endowments on output structure does not vary in a systematic way with a country's degree of openness. It also required a new econometric specification, which was applied to data covering most of the world's countries during 1985–2014 (and could potentially be used with other data and for other research purposes).

The results confirm that greater openness, across and within countries, strengthens the tendency for a higher land–labour ratio to reduce the manufactured–primary output ratio, and also show that this effect is substantial. In a very land-abundant country, the share of manufacturing in the value of goods output would be 11 percentage points lower with a trade policy at the top decile of openness than at the bottom decile of openness.

A proper analysis of the second causal link – that a larger primary output share tends to slow or prevent development – is beyond the scope of this paper. However, the data and regression

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specification used in this paper permit a simple test of both causal links combined by changing the dependent variable from the manufactured–primary output ratio to per capita GDP (in 2005 US dollars). The results are in Table A7 of the online Appendix.

The average cross-section results must be interpreted with caution because of endogeneity and omitted variables. The variation in per capita GDP levels is not at PPP, and the only significant coefficients are on schooling and trade policy. But there is no evidence of openness worsening a malign cross-country relationship between land abundance and per capita income. This result conforms with casual observation of high land–labour ratios and high exposure to trade both in some of the world's poorest countries (in Africa) and in some of its richest countries (in North America, Oceania, and Scandinavia).

A less encouraging conclusion for land-abundant developing countries emerges from the level-change (LVCH) regressions. Although the estimates are imprecise, per capita GDP growth during 1985–2014 was inversely related to land abundance – as in the 'resource curse' literature – and more so in countries that adopted more open policies. All countries tended to gain from greater openness, but these gains were larger in land-scarce countries.

The practical implications of this LVCH result should not be overstated: the coefficients imply that the net effect of greater openness on growth was negative only in the most land-abundant quarter of developing countries. Moreover, the pattern of greater openness contributing more to growth in land-scarce developing countries might not persist: it could reflect just a one-off transfer of manufacturing technology from developed countries during 1985–2014.

Even if greater openness continues to slow the growth of land-abundant developing countries by reducing their manufactured output shares, the implications for trade policy are debatable. Today's international fragmentation of manufacturing would preclude replication of the earlier sectoral protection that arguably helped some now-open land-abundant developed countries to acquire manufacturing capabilities, though 'soft' and sub-sectoral industrial policies might still achieve similar results (e.g., Harrison and Rodriguez-Clare, 2010; Mayer, 2021).

The ever-increasing tradability of services has made them a potential alternative or complement to manufacturing in the process of development (e.g., Baldwin and Forslid, 2023). However, it is unlikely that exporting services could offset the comparative disadvantage in manufacturing of land-abundant countries, because the service sector shares with manufacturing much lower land intensity than primary production. The key distinction is therefore between the primary sectors and the combination of manufacturing and modern services.

Regardless of whether and how trade policies should differ between land-abundant and land-scarce developing countries, some other sorts of policies should differ (Wood, 2003). In land-abundant countries, more supply-side effort on schooling is needed because specialization in primary production reduces the demand for education (Blanchard and Olney, 2017). Their lower population density also requires more infrastructure per head. More abundant natural resources could finance this additional spending, but whether that happens depends on political choices (e.g., Cabrales and Hauk, 2011; Dercon, 2022).

Supplementary Materials. To view supplementary material for this article, please visit https://doi.org/10.1017/S1474745623000095.

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