Capital Taxes, Trade Costs and the Irish Miracle

John Romalis, August 2006*

Abstract

This paper uses detailed international trade data to examine whether the rapid growth of Ireland in the 1990’s and its accompanying substantial increase in trade in goods and services might have been spurred by an interaction of low taxation of capital and declining international trade costs. Both tariffs and other trade costs for an important class of goods and services have declined to very low levels in the 1990s, while the expansion of foreign direct investment worldwide in that period suggests a great drop in technological and policy barriers to managing international production. The decline in trade costs has profound effects on small economies that also levy low levels of capital taxation. Such economies exhibit a great increase in the production and export of products that have high capital intensity. This implication receives strong support in detailed trade data. The expansion of such modern, high labor-productivity sectors has been identified as an important recent feature of Irish growth.

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Ireland’s output per capita was little more than half the average for industrial countries in the 1970’s. But gradually from the late 1980’s and much more rapidly from 1995 Ireland has risen towards and then above the average for these countries (Figure 1). An extensive analysis of this performance by Patrick Honohan and Brendan Walsh (2002) suggests that this improvement can be decomposed into higher labor-force participation, higher educational qualifications of the labor force, and a movement of the labor force into modern high-productivity sectors such as export driven manufacturing and market services - often facilitated by foreign direct investment (FDI). The underlying cause of this performance has been harder to identify.

Honohan and Walsh decline to identify a single magic ingredient for Ireland’s growth, but rather point to a range of generally market friendly policies that combined with the elimination of the barriers created by the unsustainable trajectory of public debt and taxation in the 1980s. The main ingredients they identify include: the quality of Irish education; the quality of Irish public administration and legal and financial institutions; a fall in age-dependency; tax concessions for exporters; better external conditions; wage moderation and industrial harmony from the mid-1980s; and better macroeconomic management from the late-1980s. Other factors that may have played a part were the devaluations in 1986 and 1993; greatly expanded EU structural adjustment funds from 1988; FDI promotion; and even growth in tourism receipts. Olivier Blanchard (2002) identifies wage moderation as the “trigger” or proximate cause of the Irish boom. While undoubtedly important, the wage moderation story potentially has a troublesome fact to deal with. Wage moderation should lead to a decline in capital-to-labor ratios within industries in Ireland, which is observed, but it should also lead to a relative decrease in costs and therefore increase in the competitiveness of labor-intensive industries. Quite the opposite is observed in international trade data.

This paper picks up on an important fact that is recognized by Honohan and Walsh - the extremely rapid growth of Ireland’s international trade and inward FDI. Honohan and Walsh note that net exports were a major contributor to demand growth, and that export growth appears to precede growth in private consumption and investment. Furthermore, they pay attention to the likely stimulus provided by inward FDI. Foreign-owned firms account for half of Irish manufacturing employment, most manufacturing exports and even 7 percent of total tax revenues. The quality of their investment, management processes and skills is also likely to have had wider benefits for the Irish economy. Frank Barry (2004) goes further and argues that export-platform FDI has been one of the most important factors generating Ireland’s remarkable growth, both directly and through many positive interactions with indigenous firms and public finance.

The growth of Ireland’s external trade and inward investment in the 1990s can be explained by simultaneous developments. This paper argues that an important trigger has been a decline in technological and policy barriers to international trade in
goods and services in the 1990s. The paper provides a model and empirical evidence in support of that argument. An economy that is characterized by low taxation of capital (and which has no other flaws that implicitly tax capital) becomes an ideal location for export-based capital intensive industries when trade costs are low. The savings on capital taxes outweigh the trade costs incurred by exporting the products from that country. Declining trade barriers can lead to a dramatic shift of capital intensive industries to countries that have low taxes on capital. The shift of these industries leads to increased demand for labor - which leads to higher wages if the labor force is fixed or higher employment if the labor force can be expanded.

Average trade costs in the 1990’s have declined. Figure 2 shows average international transport costs and US tariffs for goods sent from Ireland to the US as a percentage of the value of the goods shipped. A decline in policy barriers from 1995 is evident following the completion of the Uruguay Round of trade negotiations - many products can now be sold to a large number of countries duty-free. The surge in Irish trade and inward FDI since then has been remarkable. Declining EU trade barriers are also critical. While Ireland has faced zero-tariffs in the EU since 1973, the EU has been busy in the 1990’s implementing its Single Market Program, reducing many non-tariff barriers that hindered investment flows and trade in goods and services. Duties on imported inputs were also reduced following the Uruguay Round. Technological barriers have also become less important for Irish trade - an important class of goods and services can evidently be traded with negligible trade costs, while the dramatic expansion of FDI worldwide in the 1990s (UNCTAD, 2005) suggests a great drop in technological and policy barriers to managing international production.

This paper develops a many-sector model based on John Romalis (2004), who integrated a many-country version of the Heckscher-Ohlin model with a continuum of goods with Paul Krugman’s (1980) model of monopolistic competition and transport costs. That model was developed to enable detailed international trade data to be used to make inferences about important mechanisms driving the production structure of an economy - relative factor abundance in that case. Subsequent papers taking a similar empirical approach include Andrei Levchenko (2004) and Nathan Nunn (2005) who study the effect of institutional quality on production, and Alejandro Cunat and Marc Melitz (2006) who study the impact of labor market flexibility on production. In this paper one factor, capital, is allowed to be mobile, and countries may also differ in their rates of capital taxation. Different rates of capital taxation, when combined with different capital intensities in production, are a powerful force generating international trade. The model can be used to analyze the effects of declining trade costs on a small economy that levies low taxes on capital. Its international trade begins to expand greatly (Figure 3). Trade becomes skewed towards capital-intensive exports (Figure 4). Much investment is attracted from abroad (Figure 5). Movement of capital intensive industries from abroad greatly expands GDP, though GNI will expand by much less (Figure 1). Figures 1 to 5 are loosely consistent with the model, but stronger support for the model’s mechanism can be found in detailed international
trade data combined with industry-level data on the capital intensity of production. US international trade data is particularly useful because it is provided together with measures of both trade barriers, and because the US has become a major export destination for Ireland (Figure 3). The model predicts that an interaction of trade costs and capital intensity should be an important explanator of Irish exports. Irish production and exports of capital intensive products will expand rapidly as trade costs decline - much more rapidly than exports of products that more intensively use labor. Detailed trade data strongly exhibits this pattern.

The paper is organized as follows. Section I develops the model. Section II presents and discusses the empirical evidence. Section III concludes.

I. The Model

A. Model Description

The model is a many-industry model with two factors of production, capital and labor, similar to Romalis (2004). Romalis (2004) integrated a many-country version of the Heckscher-Ohlin model with a continuum of goods with Krugman’s (1980) model of monopolistic competition and transport costs. In this paper one factor, capital, is allowed to be mobile. Countries differ in their rates of capital taxation. When combined with different capital intensities in production, capital taxes will be a force generating international trade. The model assumptions are set out in detail below.

1. There are $2M$ countries, $M$ each of “small” and “large” economies. Large countries have larger labor forces. Variables for large economies, where needed, are marked with an asterisk.

2. There are two factors of production; labor is supplied inelastically in each economy while capital is perfectly mobile between economies. Capital and labor earn factor rewards $r$ and $w$ respectively. The total labor supply in each small country is normalized to 1 and in each large country is $N^*$. The world supply of capital is inelastic and equal to $K$. All workers own an equal share of the world capital stock.

3. There is a continuum of industries $z$ on the interval $[0,1]$. The index $z$ ranks industries by factor intensity. Industries with higher $z$ are more capital intensive.

4. All consumers in all countries are assumed to have identical Cobb-Douglas preferences with the fraction of income spent on industry $z$ being $b(z)$ (Equation 1). Expenditure shares for each industry are therefore constant for all prices and incomes. All income is spent so the integral of $b(z)$ over the interval $[0,1]$ is 1.

$$U = \int_{0}^{1} b(z) \ln Q(z) dz. \quad (1)$$
5. Monopolistic competition. There are scale economies in production and firms can costlessly differentiate their products. The output of each industry consists of a number of varieties that are imperfect substitutes for one another. The quantity produced of variety $i$ in industry $z$ is denoted by $q^s(z, i)$, the quantity consumed by $q^D(z, i)$. $N(z)$ is the endogenously determined number of varieties in industry $z$:

$$N(z) = M(n(z) + n^*(z)).$$  \hspace{1cm} (2)

$Q(z)$ is a sub-utility function that depends on the quantity of each variety of $z$ consumed. I choose the symmetric CES function:

$$Q(z) = \left( \int_0^{N(z)} q^D(z, i)^\theta di \right)^{\frac{1}{\theta}}, \quad \theta \in (0, 1].$$  \hspace{1cm} (3)

Products are produced using both factors of production with a constant marginal cost and a fixed cost. Production technology, represented by a total cost function $TC$, is assumed to be Cobb-Douglas in both factors and identical in all countries:

$$TC(q^S(z, i)) = (\alpha + q^S(z, i))r^zw^{1-z}. \hspace{1cm} (4)$$

This cost function has the convenience of generating factor shares that do not depend on factor rewards. The index $z$ ranks industries by capital intensity, because $z$ denotes both the industry and capital’s share of income in that industry. There is free entry into each industry, so in equilibrium profits are zero.

6. Costly international trade. Trade costs are introduced as an iceberg transport cost: $\tau$ units of a good must be shipped for 1 unit to arrive in any other country ($\tau \geq 1$).

7. Capital taxation. Governments tax the earnings of capital located within their country at rate $t$. Tax revenue is rebated as a lump-sum back to domestic and foreign taxpayers. The government of country $i$ rebates taxpayers from country $j$ the average amount of tax that country $j$ taxpayers pay in country $i$.$^1$

B. Equilibrium in an Industry

In general equilibrium consumers maximize utility, firms maximize profits, all factors are fully employed and the current account is balanced. The model solution proceeds in two steps. The first step is to solve for the partial equilibrium in an arbitrary industry. I solve for the share of world production that each country commands,

$^1$Including foreign taxpayers in the rebate simplifies the task of computing the general equilibrium.
conditional on relative production costs. Countries with lower costs capture larger market shares. I then numerically solve for the general equilibrium.

The properties of the model’s demand structure have been analyzed in Helpman and Krugman (1985).\(^2\) Four additional pieces of notation are useful. Denote the (constant) elasticity of substitution between varieties within an industry by \(\sigma = \frac{1}{1-\theta}\); let \(\hat{p}(z,i)\) be the price paid by consumers, inclusive of transport costs, for variety \(i\) in industry \(z\), let \(I(z)\) be the set of all varieties in industry \(z\), and let national income be \(Y\). Maximization of \(Q(z)\) conditional on expenditure \(E(z)\) yields the following demand functions:

\[
q^D(z,i) = \frac{\hat{p}(z,i)^{-\sigma}}{\int_{i' \in I(z)} \hat{p}(z,i')^{-\sigma} d\hat{p}(z,i')^{-\sigma} E(z)}; \quad i \in I(z). \tag{5}
\]

A firm’s share of industry revenues depends on its own price and on the prices set by all other firms in that industry. Due to the unit elasticity of substitution between industries, a constant fraction of income \(b(z)\) is spent on industry \(z\) in every country. An individual small-country firm sets a single factory gate price of \(p\). Its products sell in its own domestic market at \(p\), but in the \(M - 1\) other small markets and the \(M\) large markets the transport cost raises the price to \(p\tau\). The ideal industry price index \(G\) is given in Equation 6. \(G^*\) is symmetric. Implicit in these indices is the assumption that in equilibrium all small countries are alike and all large countries are alike. Except where needed, the ‘\(z\)’ notation is suppressed.

\[
G = \left[ np^{1-\sigma} + (M - 1) n (p\tau)^{1-\sigma} + M n^* (p^*\tau)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{6}
\]

The revenue of a typical small-country firm that sets a factory gate price of \(p\) is given by Equation 7. The three terms reflect revenues in its domestic market, the \(M - 1\) other small markets and the \(M\) large markets. The equivalent large-country expression is symmetric.

\[
pq^S = bY \left( \frac{p}{G} \right)^{1-\sigma} + (M - 1) bY \left( \frac{p\tau}{G} \right)^{1-\sigma} + M bY^* \left( \frac{p^*\tau}{G^*} \right)^{1-\sigma}. \tag{7}
\]

The production and trade structure has also been studied in Helpman and Krugman (1985).\(^3\) Each firm produces a different variety of the product. Each country, if it produces in the industry at all, produces different varieties. Every variety is demanded in every country. Profit maximizing firms perceive a demand curve that has a constant elasticity, and therefore set price at a constant markup over marginal cost:

\(^2\)See Sections 6.1, 6.2 and 10.4 in particular.
\(^3\)See Chapter 7.
\[ p(z) = \frac{\sigma}{\sigma - 1} r^z w^{1-z} \]  

(8)

With free entry, profits are zero in equilibrium. The pricing rule, the zero profit condition and the special form of the fixed cost produce an equilibrium where all firms produce the same quantity of output:

\[ q^S = q^{S*} = \alpha(\sigma - 1). \]  

(9)

We can now solve for the partial equilibrium in this industry. Notation is simplified by defining world income \( W = M(Y + Y^*) \), the relative price of small-country goods \( \tilde{p} = \frac{p}{\tilde{p}^*} \) and the expression \( F = 1 + (M - 1) \tau^{1-\sigma} \). Conditional on prices, Equations 6 and 7 and their symmetric large-country analogues contain four equations in four unknowns \( n, n^*, G \) and \( G^* \). These equations may not have positive solutions for both \( n \) and \( n^* \). If they do not, the solution for \( n \) and \( n^* \) will either be Equation 10 or Equation 11. If \( \tilde{p} \) is low then Equation 10 is the solution; if \( \tilde{p} \) is high then Equation 11 is the solution.\(^4\)

\[ n = \frac{b(Y + Y^*)}{p^* \alpha(\sigma - 1)}, \quad n^* = 0 \quad \text{if} \quad \tilde{p} \leq \bar{p} = \left[ \frac{\tau^{1-\sigma} MF \left( \frac{Y^*}{Y} + 1 \right)}{\tau^{2-\sigma} M^2 + F^2 \frac{Y^*}{Y}} \right]^{\frac{1}{\sigma}}. \]  

(10)

\[ n = 0, \quad n^* = \frac{b(Y + Y^*)}{p^* \alpha(\sigma - 1)} \quad \text{if} \quad \tilde{p} \geq \bar{p} = \left[ \frac{\tau^{2-2\sigma} M^2 \frac{Y^*}{Y} + F^2}{\tau^{1-\sigma} MF \left( \frac{Y^*}{Y} + 1 \right)} \right]^{\frac{1}{\sigma}}. \]  

(11)

If both \( n \) and \( n^* \) are positive, Equations 6, 7 and 9 solve for \( \frac{n}{n^*} \), which is given in Equation 12. This expression is derived by dividing the demand Equation 7 by its large-country equivalent; substituting for \( q^S \) and \( q^{S*} \) using Equation 9; substituting for \( G \) and \( G^* \) using Equation 6; and rearranging. The relative number of small-country firms declines in both the relative price of small-country goods and in the relative size of large economies.

\[ \frac{n}{n^*} = \frac{\tau^{2-2\sigma} M^2 \frac{Y^*}{Y} + F^2 - \tilde{p}^\sigma \tau^{1-\sigma} MF \left( \frac{Y^*}{Y} + 1 \right)}{\tilde{p} \left( \tau^{2-2\sigma} M^2 + F^2 \frac{Y^*}{Y} \right) - \tilde{p}^{1-\sigma} \tau^{1-\sigma} MF \left( \frac{Y^*}{Y} + 1 \right)}, \text{ if } \tilde{p} \in (\underline{p}, \bar{p}). \]  

(12)

Equations 10-12 can be used to solve for the share \( v \) of world revenues in that industry that accrue to firms in each small country. When solving for \( v \), we have to

\(^4F \) is the quantity of goods a small-country firm sells in all small markets divided by its domestic sales; \( F > M \tau^{1-\sigma} \).

\(^5\) The conditions for \( \tilde{p} \) are derived from Equation 12.
account for the indirect demand for goods used up in transit. Each small-country firm’s revenue is given by \( pq^S \), where \( q^S \) is the quantity produced, not the quantity consumed. Equation 13 is the definition of \( v \). Equation 14 is the solution for \( v \).

\[
v = \frac{npq^S}{M (npq^S + n^*p^*q^S*)} \tag{13}
\]

\[
v = \begin{cases} 
\frac{1}{M} & \text{if } \bar{p} \in (0, \bar{p}] \\
\frac{Y}{W} \left[ \frac{-p^* r^1 - s MF(Y^* + 1) + r^2 - 2s M^2 Y^* + F^2}{-(p^* + p - s) r^1 - s MF + r^2 - 2s M^2 + F^2} \right] & \text{if } \bar{p} \in (\bar{p}, \bar{p}) \\
0 & \text{if } \bar{p} \in [\bar{p}, \infty) 
\end{cases} \tag{14}
\]

The revenue share \( v \) declines in both the relative price of small-country goods \( \bar{p} \) and the relative size of large economies \( \frac{Y^*}{Y} \). Market share responds negatively to relative price. But by Equation 8, relative price is equal to relative production costs, which depend on factor prices. This generates the role for capital taxes.

\[ C. \text{ General Equilibrium} \]

Since capital is mobile, the net return to capital must be the same in all countries (Equation 15). All factors must be fully employed. With assumed preferences, the fraction of world income spent on each industry is invariant to prices and income. With the assumed production technology, factor shares in each industry are invariant to factor prices. Capital’s share of revenues in industry \( z \) is constant and equal to \( \frac{z}{z} \). The balance goes to labor. Equations 16 to 18 are, respectively, the full employment conditions for: labor in small countries; labor in large countries; and capital. The left side of each equation is factor demand, the right is factor supply. The wages of labor in large countries have been normalized to 1. National income equals national expenditure in every country, so the current account is balanced.

\[
r (1 - t) = r^*(1 - t^*) \tag{15}
\]

\[
\int_0^1 \frac{1}{w} (1 - z) b(z) W v(z) \, dz = 1 \tag{16}
\]

\[
\int_0^1 (1 - z) b(z) W \left( \frac{1}{M} - v(z) \right) \, dz = N^*. \tag{17}
\]
When small and large countries tax capital equally, capital tends to migrate to the large countries. This is because producers in the model’s increasing-returns framework want to be proximate to major markets - much mobile capital moves from small countries while immobile labor must remain. Figure 6 illustrates the equilibrium where all countries tax capital at the rate of 30 percent and where trade costs are high at 50 percent of value-added. Small countries almost exclusively produce labor-intensive products. The migration of capital to larger countries results in per-capita GDP being less than half of large-country levels, which is mostly due to lower income of capital located in those countries but also due to a large depression of real wages.

When a small country lowers taxes on capital to beneath the levels charged in large countries this may offset the market access advantages of large countries and therefore allow small countries to attract capital-intensive sectors. Figure 7 illustrates the equilibrium when taxes in small countries have been reduced to 12 percent while taxes in large countries remain at 30 percent. In this model this tax advantage is enough to attract capital from large countries, and as a result per-capita GDP in small countries rises through both an increase in real wages and through an increase in the amount capital located in these countries. But large trade costs still result in large markets preserving most of their capital-intensive industries. As trade costs fall though the advantage of locating in large markets diminishes, so that the location of capital is mostly driven by favorable taxation of capital. This is starkly illustrated in Figure 8 where trade costs have been reduced to 10 percent of value added - the most capital intensive sectors have entirely migrated to small countries due to their lower tax rate, which more than offsets the trade costs incurred from having to export most output back to large countries. Per-capita GDP rises dramatically in the small country, in this example to more than 5 times that of the large countries, partly due to a rise in real wages but mostly through the direct effect of the migration of much of the world's capital to the low-tax countries.

II. Empirical Evidence

Figures 1 to 5 provide some suggestive evidence that low capital taxation interacted with declining trade barriers may be an important contributor to Ireland’s recent rapid growth. Since the Irish tax rate on foreign capital has been low for decades it alone can not explain why the most impressive growth performance occurred in the mid to late 1990s (Figure 1). This was a period where measured international trade costs for a broad class of goods (not to mention services) became very small (Figure 2). Other important policy and technological barriers to Ireland’s international trade may also have declined due to, for instance, the EU’s Single Market Program, EU
tariffs on imported inputs, and improved information and telecommunication technology. The declining trade barriers helped induce a very rapid expansion of Ireland’s exports (Figure 3), including a very pronounced increase in the capital intensity of Ireland’s exports (Figure 4). The capital required to produce these exports was not all provided domestically - much of it came from abroad (Figure 6). This is consistent with the mechanism in the model.

Stronger support for the model’s mechanism can be found in detailed international trade data combined with industry-level data on the capital intensity of industries. US international trade data is particularly useful because it is provided together with measures of trade barriers, and because the US has become a major export destination for Ireland (Figure 3). The model essentially predicts that Irish production and exports of capital intensive products will rapidly expand as trade costs decline, whereas exports of goods that intensively use other factors will increase less rapidly and may in fact decline as these factors are demanded by expanding capital intensive sectors.

US international trade data comes complete with the amount of import duties actually paid together with a measure of international freight charges - the difference between the CIF and the FOB value of international trade divided by the FOB value. This data is easily merged with data from the NBER’s Manufacturing Industry Productivity Database, which contains information on the capital intensity of US manufacturing industries at the 4-digit SIC level up to 1996. I use the 1996 NBER data. I look to each product in the US trade data for 1989 to 2001 and calculate the share of US imports of that product that comes from Ireland, together with the tariff costs for imports of that product from Ireland and international freight costs. If the US does not import a product from Ireland in a given year I use the US MFN tariff for that product as the measure of the US tariff on imports from Ireland. Since freight costs are only observed where there is trade I use the freight costs for all US imports of a product even when I observe trade from Ireland. Since freight costs depend on the volume of international trade I avoid an endogeneity problem by either only using the tariff component of the international trade costs, or when I use both components I use the tariff component to construct instruments. I run regressions of the following form:

\[
\text{IrelandShare}_{it} = \alpha \frac{K}{L_i} \tau_{it} + \beta \tau_{it} + D_i + D_t + \epsilon_{it} \tag{19}
\]

where \(\text{IrelandShare}_{it}\) is the share of US imports of product \(i\) at year \(t\) that comes from Ireland; \(\frac{K}{L_i}\) is the amount of capital used in industry \(i\) in the US in 1996 (measured in hundreds of thousands of dollars) divided by the employment in that industry in the US in 1996; \(\tau_{it}\) is cost of shipping product \(i\) from Ireland to the US in year \(t\); and \(D_i\) and \(D_t\) are full sets of product and year dummies respectively. Note that product dummies would completely absorb \(\frac{K}{L_i}\) if it were included.
The model predicts a negative value for $\alpha$ - since Ireland levies low taxes on capital, lower tariffs cause a relative expansion in Irish exports of capital-intensive products. Results reported in Table 1 show that this prediction is strongly borne out in the data. Moreover, the effect is very large. Results in columns 1-2 are OLS regressions where tariffs are the only measure of trade costs. For a product at the 90th percentile of capital intensity ($328,000 per employee in 1996), the estimates in the first column suggest that a 5 percentage point trade cost reduction would increase the share of US imports coming from Ireland by 4.4 percentage points, whereas Ireland’s share of imports of products at the 10th percentile of capital intensity ($18,000 per employee) would contract by 1.0 percentage points. The estimates in the second column, which uses a slightly different functional form by employing logarithms of explanatory variables, suggest that a 5 percentage point trade cost reduction leads to a 3.7 percentage point increase in Ireland’s share at the 90th percentile and a 2.1 percentage point decrease at the 10th percentile of capital intensity. Since Ireland only captured a 0.5 percent share of US imports over this period this impact is substantial.

The results in columns 3 and 4 of Table 1 are IV regressions where trade costs are both the sum of the tariff and freight costs, and where this sum has been instrumented with the tariff component alone. These estimates suggest a slightly smaller impact of a reduction of trade costs. The third column results suggest that the same 5 percentage point tariff reduction leads to a 3.0 percentage point expansion of Ireland’s share at the 90th percentile of capital intensity and a 0.5 percentage point contraction at the 10th. The results in the fourth column suggest a 2.7 percentage point expansion and 1.3 percentage point contraction respectively. Columns 5-6 are similar to columns 1-2, but with an added interaction of skill-intensity (measured as the proportion of non-production workers in the industry) with trade costs to address the concern that it is really skill-intensity that has been driving Ireland’s export performance in the 1990’s. The skill variables have little effect. Columns 7-8 exclude some major intellectual property (IP) intensive industries which may have located in Ireland simply to reduce taxes on the returns to IP created elsewhere - pharmaceuticals, computers and office machines, software, and medical equipment. The results are again similar.

The declining trade costs for a broad range of products evident in Figure 2 could have been one of the major contributors to the migration of export-oriented capital intensive industries to Ireland due to Ireland’s low rate of tax on capital. Since exports are now a very substantial proportion of Ireland’s GDP, this could have very directly contributed to Ireland’s recent growth performance. The migration of such industries to Ireland is also a major component of the expansion of employment in modern sectors identified by Honohan and Walsh (2002) and Barry (2004) as an important feature of Ireland’s growth.

III. Conclusion

This paper examines whether a substantial part of Ireland’s growth in the 1990’s might be explained by an interaction of low taxation of capital and declining interna-
tional trade costs. Both tariffs and other trade costs for an important class of goods and services have declined to very low levels in the 1990s. A decline in trade costs has profound effects on small economies that also levy low levels of capital taxation. The inward migration of capital leads to a great increase in the production and export of products that exhibit high capital intensity. This implication receives strong support in detailed trade data. These sectors also have very high ratios of value added to labor. The expansion of such modern, high labor-productivity sectors has been identified as an important recent feature of Irish growth.
Data Appendix

US international trade and tariff data are from the UC Davis Center for International Data. The US MFN tariff for a product is calculated as the median tariff applied where no preferential tariff was claimed. Transport costs are calculated as $1 - \frac{FOB}{CIF}$ values of US imports of a product.

EU international trade data are from Eurostat’s COMEXT database.

Capital-Labor ratios and the proportion of production workers for 4-digit SIC industries for 1996 are from the NBER’s Manufacturing Industry Productivity Database.

Data on GDP, GNI, FDI, Employment and Population are derived from the World Bank’s World Development Indicators.
References


### Table 1: Declining Trade Barriers and the Capital Intensity of Irish Exports, 1989-2001

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>(1) IrelandShare</th>
<th>(2) IrelandShare</th>
<th>(3) IrelandShare</th>
<th>(4) IrelandShare</th>
<th>(5) IrelandShare</th>
<th>(6) IrelandShare</th>
<th>(7) IrelandShare</th>
<th>(8) IrelandShare</th>
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<tr>
<td><strong>Explanatory Variable</strong></td>
<td><strong>Dependent Variable</strong></td>
<td><strong>(1) K/L*Tradecost</strong></td>
<td>*<em>(2) ln(K/L)<em>ln(1+Tradecost)</em></em></td>
<td><strong>(3) Skill*Tradecost</strong></td>
<td>*<em>(4) ln(Skill)<em>ln(1+Tradecost)</em></em></td>
<td><strong>(5) Tradecost</strong></td>
<td><strong>(6) ln(1+Tradecost)</strong></td>
<td><strong>(7) Product fixed effects</strong></td>
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<td><strong>K/L*Tradecost</strong></td>
<td>*<em>ln(K/L)<em>ln(1+Tradecost)</em></em></td>
<td>-0.347*** (0.056)</td>
<td>-0.388** (0.171)</td>
<td>-0.025 (0.468)</td>
<td>-0.111 (0.145)</td>
<td>0.252*** (0.049)</td>
<td>-0.262** (0.125)</td>
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<tr>
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<td>-0.224*** (0.044)</td>
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<td>-0.142*** (0.030)</td>
<td>-0.204** (0.104)</td>
<td>0.142*** (0.030)</td>
<td>-0.394 (0.245)</td>
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<tr>
<td><strong>Skill*Tradecost</strong></td>
<td>*<em>ln(Skill)<em>ln(1+Tradecost)</em></em></td>
<td>-0.346*** (0.054)</td>
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<td>*<em>ln(Skill)<em>ln(1+Tradecost)</em></em></td>
<td><strong>Tradecost</strong></td>
<td>-0.374*** (0.035)</td>
<td>-0.452*** (0.142)</td>
<td>-0.111 (0.145)</td>
<td>-0.394 (0.245)</td>
<td>0.266*** (0.040)</td>
<td>-0.303*** (0.102)</td>
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</tr>
<tr>
<td><strong>Tradecost</strong></td>
<td><strong>ln(1+Tradecost)</strong></td>
<td>-0.262** (0.125)</td>
<td>-0.204** (0.104)</td>
<td>-0.266*** (0.040)</td>
<td>-0.303*** (0.102)</td>
<td>0.258** (0.124)</td>
<td>-0.394 (0.245)</td>
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<tr>
<td><strong>ln(1+Tradecost)</strong></td>
<td><strong>Product fixed effects</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td><strong>Year fixed effect</strong></td>
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<td>Yes</td>
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<td><strong>Trade cost measure</strong></td>
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<td><strong>IP Sectors</strong></td>
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<td>Yes</td>
<td>No</td>
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<tr>
<td><strong>R²</strong></td>
<td><strong>R²</strong></td>
<td>0.589</td>
<td>0.586</td>
<td>-</td>
<td>-</td>
<td>0.589</td>
<td>0.586</td>
<td>0.605</td>
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<tr>
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<td>181861</td>
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<td><strong>Number of products</strong></td>
<td><strong>Number of products</strong></td>
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<td>20405</td>
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Notes: Columns 1-2 report results from OLS regressions of Ireland’s share of US imports at the US tariff-line level (“IrelandShare”) on an interaction of the capital-labor ratio of the 4-digit industry which produces the product and a measure of “Tradecost” - the US tariff on imports of that product from Ireland. Columns 3-4 report results from similar IV regressions, but where “Tradecost” is the sum of the US tariff on imports from Ireland and the difference between CIF and FOB prices for all US imports of that product. Since the CIF/FOB price difference depends on the value shipped, the tariff component of this measure is used to construct instruments for “Tradecost” and its interactions with the capital-labor ratio. Columns 5-6 add an interaction of skill intensity (proxied by the proportion of non-production workers in the industry) with “Tradecost”. Columns 7-8 delete products which have a high intellectual-property (IP) content and a high propensity to be located in Ireland to reduce taxes on the returns to that IP: pharmaceuticals (HS Chapter 30); computers and office machines (HS Headings 8469-8473); software (HS Heading 8524); and medical equipment (HS Headings 9018-9022). Standard errors clustered at the 4-digit SIC level are reported in parentheses. ***, **, and * denote significance at the 1, 5 and 10 percent levels respectively. US trade and tariff data is from The Center for International Data at UC Davis, while the capital to labor ratio and the proportion of non-production workers is from the final year (1996) of the NBER productivity database. Product fixed effects would absorb the capital-labor ratio and skill measure if they were included separately in the regression.
Figure 1: Ireland’s Income Relative to High-Income OECD

Figure 2: Declining Trade Costs

Figure 3: Ireland’s Exports and GDP

Figure 4: Capital Intensity of Ireland’s and Other-EU Exports