# The Uneven Pace of Deindustrialization in the OECD [*]

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**Abstract**

Throughout the OECD, the period since the 1970s saw a secular decline in manufacturing's share of GDP and a secular rise in the share of services. Despite this being a central feature of growth, the economic forces behind deindustrialization and the reasons why its pace varied so markedly across OECD countries are not well understood. Adopting an econometric approach founded in neoclassical production theory, we provide empirical evidence on how changes in technology, relative prices and factor endowments (in particular, educational attainment) interacted with national labour market institutions. We show how higher employment protection slowed structural change.

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# 1. Introduction

A central feature of economic growth in industrialized countries since the early 1970s has been the secular decline in manufacturing's share of GDP and the secular rise in the share of service sectors. Though this phenomenon is well known, the economic forces behind deindustrialization and the reasons why its pace varied so markedly across OECD countries are not well understood. While the United Kingdom and United States were quick to 'de-industrialize', Germany and Japan have retained larger shares of manufacturing in GDP. What explains these differences in the evolution of production structure across OECD countries and what role (if any) did national policies and institutions play? Adopting an econometric approach founded in neoclassical production theory, we provide empirical evidence on how changes in technology, relative prices and factor endowments (in particular, educational attainment) interacted with national labour market institutions to shape the uneven pace of deindustrialization.

Our approach enables us to decompose the observed variation in rates of deindustrialization into the contributions of individual explanatory variables. We find that the more rapid decline in manufacturing's GDP share in the United Kingdom and United States is largely explained by differences in industry total factor productivity (TFP) growth. The above average rates of decline in agriculture's share of GDP in Italy and Japan are largely accounted for by patterns of industry TFP growth and movements in relative prices. Educational attainment plays an important role in explaining the differential growth of service sectors as a share of GDP, consistent with many service sector activities being relatively skill-intensive.

The pattern of estimation results accords with theoretical priors. The effects of own industry technology and relative price are positive and statistically significant, and there is evidence that our theory-consistent specification constitutes a long-run cointegrating relationship. We find that male and female educational attainment have very different effects on production structure, suggesting that men and women of the same educational level differ or are perceived to differ in terms of other labour market characteristics and dimensions of human capital. This is consistent, for example, with differences between men and women in areas of specialization at school and university.

There is evidence of gradual adjustment to changes in long-run equilibrium production structure, and the speed of adjustment is found to vary systematically across countries with levels of employment protection. This suggests that labour market institutions are important in shaping the speed with which resources are reallocated from declining to expanding sectors. While much of the literature treats labour and product markets separately, our results emphasize how institutions in the labour market matter for outcomes in the product market.

The paper relates to four main strands of existing research. First, there is a relatively informal economic history literature that has examined de-industrialization, often with particular emphasis on the United Kingdom and United States.[1] With the beginning of the Industrial Revolution in the late-Eighteenth Century, the share of agriculture in UK GDP progressively declined from 18.4% in 1856 to 3.4% in 1964. The share of manufacturing in UK GDP continued to rise into the 1960s (from 22.2% in 1856 to 33.6% in 1964), with de-industrialisation emerging as a phenomenon in the 1970s.[2] While deindustrialization occurred to some degree throughout the OECD, its speed, extent and timing varied substantially across OECD countries. For example, while manufacturing's share of GDP declined by 4.5% points in the United Kingdom between 1975 and 1985, it fell by less than 1% point in Japan over the same period.

Second, the paper relates to the empirical literature examining the relationship between factor endowments and the international location of production in the Heckscher-Ohlin model or the more general neoclassical theory of trade and production. Harrigan (1995), (1997), Harrigan and Zakrajsek (2000), Redding (2002) and Schott (2003) examine this relationship at the country-level, while Bernstein and Weinstein (2002), Davis *et al.* (1997), Hanson and Slaughter (2002) and Redding and Vera-Martin (2003) undertake analyses across regions within countries. A key conclusion of this literature is that, while factor endowments matter for production structure, cross-country differences in technology are also statistically and quantitatively important.

Third, our work also relates to the labour market literature on institutions. A number of studies have emphasized the role of employment protection and job security provisions in

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[1] See, for example, Crafts (1996), Kitson and Michie (1996), Rowthorn and Ramaswarmy (1999), and Broadberry (1998). For more recent popular discussions of deindustrialization, see Owen (1999) and Turner (2000).

[2] These historical figures are from Matthews *et al.* (1982), Table 8.1.

determining the speed at which workers are reallocated from old and declining sectors to new and expanding ones.[3] Using firm-level data Hopenhayn and Rogerson (1993) find a negative effect of employment protection on aggregate productivity and growth through this mechanism. Using country-level over time, Lazear (1990) and Nickell (1997) find important effects on levels of employment and unemployment.

Fourth, a variety of labour market studies have found substantial differences between men and women. The classic example is the gender wage differential where, even after controlling for a wide range of observable characteristics (such as age, experience, industry and occupation) and for unobserved heterogeneity, men are typically found to earn more than women.[4] More generally, industry and occupation vary substantially between men and women. For example, in 1995, 71% of employees in UK manufacturing were men, compared to 42.2% in Business Services and 50% in Other Services. This variation remains after conditioning on skill levels – in 1995, the share of high skill men in UK total manufacturing employment was 13.3%, compared to 1.9% for women.[5]

Our paper makes a number of contributions to these existing literatures. First and foremost, we show how an approach based on neoclassical theory may be used to shed light on explanations for the differential speed, timing and extent of deindustrialization across OECD countries. This is important for understanding recent structural change and for thinking about implications for policy. Second, data availability means that much of the existing empirical trade literature focuses on sub-sectors of manufacturing, a relatively minor part of the OECD economies. Our concern with deindustrialization means that we simultaneously consider manufacturing, services and the other sectors that make up GDP.

Third, we provide evidence on the role of national policies – in particular, the level of employment protection provision – in helping or hindering the process of structural change. To date and in marked contrast to the labour and growth literatures, empirical trade research has devoted relatively little attention to institutions. Fourth, to deepen our understanding of the relationship between educational attainment and production structure, we make use of a

[3] See Nickell and Layard (1999) for a survey of the literature on labour market institutions.
[4] See, for example, Blinder (1973), Desai *et al.* (1999), Oaxaca (1973), Oaxaca and Ransom (1994) and Swaffield (1999).
[5] These figures on shares of employment by sex and skill level are from Tables B2 and B3 in Appendix B, which are derived from individual-level information in the United Kingdom's New Earnings Survey.

newly constructed and highly detailed dataset on 14 OECD countries that aggregates individual-level information from labour force surveys.[6]

Fifth, despite the large labour market literature on institutions and differences between men and women, there has been little attempt to examine the implications for product markets. This paper seeks to bridge this gap by examining whether employment protection does indeed inhibit long-run changes in production structure and by explicitly testing whether levels of educational attainment of men and women have the same effects on production structure.

The remainder of the paper is structured as follows. Section 2 introduces the theoretical framework, and derives an equation relating the share of a sector in a country's GDP to relative prices, technology and factor supplies. Our main econometric specification comes directly from the theoretical model and is discussed in Section 3. Section 4 describes the data and discusses cross-country differences in the magnitude and timing of structural change. Section 5 presents the main econometric results. We examine the contributions of the explanatory variables to the uneven pace of deindustrialization, and the role of employment protection in slowing structural change. Section 6 summarises our conclusions.

## 2. Theoretical Framework

The starting point for the analysis is the standard neoclassical theory of trade and production, as expounded by Dixit and Norman (1980) and Woodland (1982). Time is indexed by $t$, countries by $c \in \{1,...,C\}$, final goods by $j \in \{1,...,n\}$, and factors of production by $i \in \{1,..,m\}$. Each country is endowed with a vector of factors of production, $v_{ct}$. We allow for either perfect or imperfect competition, and production is assumed to occur under conditions of constant returns to scale.[7] We allow for differences in factor endowments across countries $c$ and technology differences across both countries $c$ and industries $j$.

General equilibrium in production is represented using the revenue function $r_c(p_{ct}, v_{ct})$, where $p_{ct}$ is a vector of industry output prices. Under the assumption that this function is twice continuously differentiable, the country's vector of profit-maximising net outputs,

[6] By exploiting microdata from country labour force surveys, we are able to avoid the concerns recently raised about standard cross-country measures of educational attainment such as Barro and Lee (1994), (2002) which are available at five-year intervals for a large number of countries: see, for example, the discussion in de la Fuente and Domenech (2000), Krueger and Lindahl (2001) and Cohen and Soto (2001).

$y_c(p_{ct}, v_{ct})$, is equal to the gradient of $r_c(p_{ct}, v_{ct})$ with respect to $p_{ct}$.[8] We allow for Hicks-neutral technology differences across countries, industries, and time. In this case, the production technology takes the form $y_{cjt} = \theta_{cjt} F_j(v_{cjt})$, where $\theta_{cjt}$ measures technological efficiency in industry *j* of country *c* at time *t*. The revenue function is given by $r_c(p_{ct}, v_{ct}) = r(\theta_{ct} p_{ct}, v_{ct})$, where $\theta_{ct}$ is an $n \times n$ diagonal matrix of the technology measures $\theta_{cjt}$.[9] Changes in technology in industry *j* of country *c* have analogous effects on revenue to changes in the price of industry *j* output.

We follow Harrigan (1997) and Kohli (1991) in assuming a translog revenue function,[10]

$$\ln r(\theta.p,v) = \alpha_{00} + \sum_j \alpha_{0j} \ln \theta_j p_j + \frac{1}{2}\sum_j \sum_k \alpha_{jk} \ln(\theta_j p_j).\ln(\theta_k p_k)$$

$$+ \sum_i \beta_{0i} \ln v_i + \frac{1}{2}\sum_i \sum_h \beta_{ih} \ln v_i . \ln v_h \qquad (1)$$

$$+ \sum_j \sum_i \gamma_{ji} \ln(\theta_j p_j).\ln(v_i)$$

where $j,k \in \{1,...,n\}$ index goods and $i,h \in \{1,...,m\}$ index factors. Symmetry of cross effects implies,

$$\alpha_{jk} = \alpha_{kj} \qquad and \qquad \beta_{ih} = \beta_{hi} \qquad \forall j,k,i,h \qquad (2)$$

Linear homogeneity of degree 1 in *v* and *p* requires,

$$\sum_j \alpha_{0j} = 1, \qquad \sum_i \beta_{0i} = 1, \qquad \sum_j \alpha_{kj} = 0 \qquad (3)$$

$$\sum_i \beta_{ih} = 0, \qquad \sum_i \gamma_{ji} = 0 \qquad (4)$$

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[7] See the Appendix for further discussion of the imperfectly competitive case.

[8] Formally, a sufficient condition for the revenue function to be twice continuously differentiable is that there are at least as many factors as goods: $m \geq n$. With $n > m$, production levels may be indeterminant, although this will depend on technology differences, trade costs and whether or not there is joint production. The potential existence of production indeterminacy is really an empirical issue. We present empirical evidence that the specification below, including relative prices, technology and factor endowments, provides a relatively successful model of patterns of production in OECD countries.

[9] See Dixit and Norman (1980), pages 137-9. Technology may vary across countries, industries and time, but technology differences are Hicks-neutral in the sense that they raise the productivity of all factors of production by the same proportion.

[10] To save notation, country-time subscripts are suppressed except where important. See Christensen *et al.* (1973) for a discussion of properties of the translog functional form.

Differentiating the revenue function with respect to $p_j$, and imposing the linear homogeneity restrictions, we obtain the following equation for the share of industry *j* in country *c* 's GDP at time *t* ($s_{cjt}$):

$$s_{cjt} = \alpha_{0j} + \sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{p_{ckt}}{p_{c1t}}\right) + \sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{\theta_{ckt}}{\theta_{c1t}}\right) + \sum_{i=2}^{M} \gamma_{ji} \ln\left(\frac{v_{cit}}{v_{c1t}}\right) \quad (5)$$

This equation is a general equilibrium relationship between the share of an industry in GDP on the left-hand side and relative prices, technology and factor endowments on the right-hand side. The coefficients on the right-hand side variables vary across industries, reflecting the fact that, in general equilibrium, an increase in the endowment of a factor or a change in relative prices will increase the output of some industries and decrease the output of others.

The theoretical analysis allows for a large number of factors of production. In particular, labour may be differentiated along a wide variety of dimensions of skills, including levels of education, types of education, general skills, vectors of industry-specific skills, physical strength, analytical skills, communication and interpersonal skills etc. In empirical work, labour endowments are typically disaggregated according to either occupation-based (non-production / production workers) or educational attainment-based measures of skills. We adopt an educational attainment-based measure of skills, and distinguish between male and female levels of educational attainment.

This allows for the possibility that male and female workers of the same education level *have* or *are perceived to have* different vectors of these other characteristics or dimensions of human capital. For example, female workers with a college degree may choose different areas of specialization to their male colleagues (e.g. English versus Engineering). Or a female worker with the same college degree as her male counterpart may be treated differently due to a different mix of other skills or labour market discrimination.[11] Since the coefficients on factor endowments are general equilibrium effects, an actual or perceived difference in levels of skills between men and women relevant for one or more industries (e.g. agriculture and mining) will result in different effects for all industries.

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[11] Ashton et al. (1998) find that female workers have above average levels of communication skills with both clients and their peers, but below average levels of manual and problem-solving skills. For US evidence on sex differentials using matched employee-employer data, see Bayard, Hellerstein, Neumark, and Troske (1999).

The theoretical analysis underlying equation (5) assumes that factors of production are perfectly mobile across industries within a country. While this may be a reasonable approximation in the long-run, it is likely in practice to take time for factors of production to reallocate from declining to expanding sectors. Equation (5) should therefore be interpreted as a long-run equilibrium relationship towards which the economy is evolving. In the empirical analysis below, we allow for a general process of dynamic adjustment towards this long-run relationship.

The translog revenue function implies coefficients on relative prices, technology and factor endowments in equation (5) that are constant across industries and over time. This is true even without factor price equalization. Indeed, with cross-country differences in technology, factor price equalization will typically not be observed. The effect of cross-country differences in relative prices and technology on patterns of production is directly controlled for by the presence of the second and third terms on the right-hand side.

The analysis so far makes no assumptions about whether countries are large or small, and allows for both tradeable and non-tradeable goods. If countries are small and all goods are freely tradeable, the vector of relative prices will be determined exogenously on world markets. With either large countries or non-tradeable goods, relative prices will be endogenous and will depend in part on a country's factor endowments and levels of technology. In the econometric analysis that follows, we control for this endogeneity with the use of instrumental variables that capture sources of variation in relative prices that are exogenous to individual countries.

## 3. Empirical Framework

### 3.1 Econometric Specification

Our econometric equation is derived directly from the theoretical framework above:

$$s_{cjt} = \alpha_{0j} + \sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{p_{ckt}}{p_{c1t}}\right) + \sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{\theta_{ckt}}{\theta_{c1t}}\right) + \sum_{i=2}^{M} \gamma_{ji} \ln\left(\frac{v_{cit}}{v_{c1t}}\right) + \varepsilon_{cjt} \tag{6}$$

where $\varepsilon_{cjt}$ is a stochastic error capturing unobserved variation in relative prices, technology and factor endowments.

Since all coefficients vary across industries, this relationship may be estimated separately for each industry *j*, pooling observations across countries *c* and time *t*. When imposing linear homogeneity in prices and technology, we normalise relative to manufacturing, so that manufacturing prices and technology are the excluded variables (manufacturing corresponds to industry 1 in equation (6)). When imposing linear homogeneity in factor endowments, we normalise relative to physical capital.

We consider a general error components specification:

$$\varepsilon_{cjt} = \eta_{cj} + d_{jt} + \psi_{cjt} \tag{7}$$

where $\eta_{cj}$ is a country-industry fixed effect, $d_{jt}$ is a {0,1} industry-time dummy, and $\psi_{cjt}$ is a mean-zero stochastic error.

The fixed effect controls for unobserved heterogeneity across countries and industries in relative prices, technology and factor endowments, which we allow to be correlated with the measured values of these variables. For example, the fixed effect will control for cross-country differences in the classification of educational attainment which may have uneven effects on the relationship between measured factor endowments and production structure across industries. The industry-time dummies control for unobserved trends in relative prices and technology that affect production structure, common changes in factor endowments across all countries that also influence specialization, and common macroeconomic shocks.

Equation (6) is a static long-run equilibrium relationship between the share of a sector in GDP, relative prices, technology and factor endowments. By construction, the share of sector *j* in GDP ($s_{cjt}$) is bounded between 0 and 1, and cannot, therefore, have a unit root. However, in any finite sample, this variable may behave like a unit root process (i.e. be I(1)). This is particularly true of our sample period (1975-94), which is characterised by a secular decline in the share of agriculture and manufacturing in GDP and a secular rise in the share of Services. Similarly, relative prices, technology, and factor endowments may all be I(1). In this case, equation (6) should be interpreted as a long-run cointegrating relationship between the share of a sector in GDP and the right-hand side variables.

In order for the equation to have this cointegrating interpretation, we require the estimated residuals from the static model to be I(0). In the empirical analysis below, we make use of panel data cointegration techniques, and employ two different panel data unit root tests. The Levin and Lin (1992) test assumes a common autoregressive parameter, while the Maddala and Wu (1999) test allows this autoregressive parameter to vary across cross-section units, as discussed further in the Appendix.

In practice, it may take time for resources to be reallocated from declining to expanding sectors. To allow for gradual adjustment towards long-run equilibrium, we also consider a dynamic specification, where equation (6) is augmented with the lagged dependent variable,

$$s_{cjt} = \alpha_{0j} + \delta_c s_{cjt-1} + \sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{p_{ckt}}{p_{c1t}}\right) + \sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{\theta_{ckt}}{\theta_{c1t}}\right) + \sum_{i=2}^{M} \gamma_{ji} \ln\left(\frac{v_{cit}}{v_{c1t}}\right) + \eta_{cj} + d_{jt} + \psi_{cjt} \qquad (8)$$

where the constant $\alpha_{0j}$ is separately identified because we impose the normalizations $\sum_c \eta_{cj} = \sum_t d_{jt} = 0$, and where $(1-\delta_c)$ corresponds to the speed of adjustment.[12] This relationship has an equivalent Equilibrium or Error Correction Model (ECM) representation,

$$\Delta s_{cjt} = (1-\delta_c)\left[s^*_{cjt-1} - s_{cjt-1}\right] + (1-\delta_c)\Delta s^*_{cjt} + \psi_{cjt} \qquad (9)$$

where $s_{cjt}^*$ denotes the long-run equilibrium value of a sector's share of GDP. Setting $s_{cjt}$ equal to $s_{cjt-1}$ in equation (8), and taking expectations so that error term $\psi_{cjt}$ is equal to zero, this long-run equilibrium value is given by:

$$s^*_{cjt} = \frac{1}{1-\delta_c}\left[\sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{p_{ckt}}{p_{c1t}}\right) + \sum_{k=2}^{N} \alpha_{jk} \ln\left(\frac{\theta_{ckt}}{\theta_{c1t}}\right) + \sum_{i=2}^{M} \gamma_{ji} \ln\left(\frac{v_{cit}}{v_{c1t}}\right) + \alpha_{0j} + \eta_{cj} + d_{jt}\right] \qquad (10)$$

We investigate whether the speed of adjustment towards long-run equilibrium varies with labour market institutions and policies that affect the reallocation of labour from declining to expanding sectors. We employ an OECD measure, which ranks countries in terms of their strength of employment protection, as listed in the Appendix.[13] Employment protection affects all sectors of the economy – agriculture and services, as well as

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[12] The presence of the lagged dependent variable on the right-hand side in this specification implies that the fixed effects estimator will be biased. Nickell (1981) shows that this bias is decreasing in the number of time periods ($T$), which in the present case is large ($T \cong 20$).

[13] See Nickell (1997) for an analysis of the relationship between this measure of employment protection and equilibrium unemployment.

manufacturing. Countries' ranking in terms of employment protection is extremely stable over time. The measure we exploit only varies in the cross-section and is based on the early 1990s. We include both the lagged dependent variable and the lagged dependent variable interacted with employment protection in our dynamic specification:

$$s_{cjt} = \delta_0 s_{cjt-1} + \delta_1 \left( emp_c \times s_{cjt-1} \right) + \sum_{k=2}^{N} \alpha_{jk} \ln\left( \frac{p_{ckt}}{p_{c1t}} \right) + \sum_{k=2}^{N} \alpha_{jk} \ln\left( \frac{\theta_{ckt}}{\theta_{c1t}} \right) + \sum_{i=2}^{M} \gamma_{ji} \ln\left( \frac{v_{cit}}{v_{c1t}} \right) + \eta_{cj} + d_{jt} + \psi_{cjt} \tag{11}$$

Any levels effects of employment protection on the share of a sector in GDP are captured in the country-industry fixed effect. A positive and statistically significant value of $\delta_1$ implies that countries with greater levels of employment protection ($emp_c$) adjust more slowly to changes in long-run equilibrium production structure. Since we employ a measure of employment protection based on the ranking of countries, which has remained extremely stable over time, this measure will not be affected by shocks to the share of sectors in GDP.[14] As robustness tests, we consider a non-parametric specification, where we interact the coefficient on the lagged dependent variable with a set of country dummies, and compare the estimated values of the coefficients with the employment protection ranking.

### 3.2 Measuring Relative Prices

To measure the price of industry *j* output in country *c* ($p_{cjt}$) we use the producer price deflator. This is an index of industry *j* prices in country *c* at time *t* relative to their value in the same country in 1990, and takes the value 1 in 1990 in all countries. It provides information on changes in nominal prices in a particular country-industry over time. It does not capture the initial level of prices across countries and industries in 1990. However, this is controlled for by the country-industry fixed effect ($\eta_{cj}$) in equations (6) and (8). When imposing linear homogeneity, we normalise the price of industry *j* output in country *c* ($p_{cjt}$) by the manufacturing price ($p_{c1t}$). This yields a measure of the evolution of relative prices

[14] Not only are country rankings extremely stable over time, but there is a high degree of correlation between the OECD measure that we employ and other rankings of countries in terms of their strength of employment protection. For example, the Spearman rank correlation coefficient between the OECD measure and an earlier ranking compiled by Bertola (1990) is 0.96, statistically significant at the 1% level.

over time, with the initial level of relative prices again captured in the country-industry fixed effect ($\eta_{cj}$).

Note that, if all goods were freely tradeable so that goods prices were the same across countries ($p_{ckt} = p_{kt}$ for all $c$), the relative price term on the right-hand side of equations (6) and (8) could be replaced with a full set of industry-time dummies. More generally, if there are constant barriers to trade across countries in individual industries, the relative price term can be replaced by industry-time dummies and a country-industry fixed effect. Thus, with a country-industry fixed effect and time dummies included in the specification of the error term, an F-test of the statistical significance of the relative price variables provides a test of the null hypothesis that relative prices only differ across countries by a constant.

As discussed above, if countries are large and/or goods are non-tradeable, relative prices will be endogenous. This gives rise to a standard simultaneity problem. Other things equal, a positive shock to the share of an industry in a country's GDP will result in a lower relative price for that industry's output, imparting a downwards bias to the estimated coefficients on relative prices. Note that this bias operates in the opposite direction to the economic relationship that we are seeking to identify – a positive supply-side relationship between the relative price of a good and the share of the sector in a country's GDP. We address the simultaneity problem using Instrumental Variables estimation. Domestic relative prices are modelled as a function of a country's own factor endowments and technology and of world relative prices.

Actual data on the cost inclusive of freight (cif) price of imports are not available for each country in our sample. Therefore, we measure world prices at the border for country $c$ as a weighted sum of the relative prices of all other countries in the sample (expressed in a common currency (dollars)), where the weights are the shares of each of the other countries in country $c$'s imports. This captures the idea that prices will vary geographically with transport costs, and the price of imports will be more closely related to prices in neighbouring countries with whom much trade occurs than to prices in distant countries with whom little trade occurs. The relationship between world and domestic prices will depend on the exchange rate and tariff levels. These are, therefore, also included in the first-stage regression, which becomes,

$$\ln\left[\frac{p_{cjt}}{p_{c1t}}\right] = \phi_{0j} + \sum_i \phi_{1ij} \ln v_{cit} + \sum_k \phi_{2kj} \ln \theta_{ckt} + \sum_k \phi_{3kj} \ln p^B_{ckt} + \phi_{4j} \ln e_{ct} + \phi_{5j} \ln \tau_{ct} + \omega_{cj} + D_{jt} + u_{cjt} \qquad (12)$$

where $p^B$ denotes the world price at the border, $e$ is the nominal exchange rate, $\tau$ is the average tariff rate, $\omega_{cj}$ is a country-industry fixed effect, $D_{jt}$ are industry-time dummies, and $u_{cjt}$ is a stochastic error. The industry-time dummies will capture the effects of forces which are common across countries, including world factor endowments which theory suggests are a determinant of world relative prices

Although the output of each of the industries in our sample is, to some extent, tradeable, the degree of tradability varies across industries (from, for example, agriculture to service sectors). The coefficients on world prices and all the other exogenous variables in the first-stage regression are, therefore, allowed to vary across industries. Note that the normalization relative to manufacturing when imposing linear homogeneity above means that we are concerned with variation in the price of each sector's output *relative to manufacturing*. Since the latter is itself highly tradeable, world prices should be important determinant of domestic relative prices, as will be shown to be the case empirically below. Since factor endowments and technology also appear independently on the right-hand side of equations (6) and (8), the identification of price effects comes from variation in world prices, exchange rates and tariffs.

The identifying assumptions underlying the instrumental variables estimation are that shocks to the share of an industry in domestic GDP do not influence world prices, exchange rates, or tariff levels. For many of our countries, where domestic production is small relative to world production of a good, these assumptions are plausible. For large economies such as the United States, the assumptions are potentially more problematic. However, a large literature documents that exchange rates respond extremely slowly to economic fundamentals such as Purchasing Power Parity, and the best prediction of a future exchange rate is its current value.[15] Furthermore, it is plausible that changes in tariffs during the sample period were largely driven by multilateral rounds of trade negotiations under the General Agreement on Trade and Tariffs and regional preferential trade agreements.

Nonetheless, shocks to the share of a sector in U.S. GDP might influence world prices, and we investigate the validity of our identifying assumptions using a Sargan test of the model's overidentifying restrictions. Another potential concern is one of weak instruments, and we also present the results of tests documenting the strength of the instruments in the first-stage regression.

### 3.3 Measuring Technology

To measure technology in sector *j* of country *c* ($\theta_{cjt}$) we employ a superlative index number measure of Total Factor Productivity (TFP) that is consistent with a translog production function.[16] In industry *j*, TFP in each country is evaluated relative to a common reference point – the geometric mean of all other countries in the industry. This is done in all years for that industry (e.g. we measure TFP in US Business Services in 1980 relative to the geometric mean of the Business Services industry across all countries in 1980) and for all industries *j*. The measure of relative TFP is given by,

$$\ln(RTFP_{cjt}) = \ln\left(\frac{Y_{cjt}}{\overline{Y}_{jt}}\right) - \overline{\sigma}_{cjt}.\ln\left(\frac{L_{cjt}}{\overline{L}_{jt}}\right) - (1-\overline{\sigma}_{cjt}).\ln\left(\frac{K_{cjt}}{\overline{K}_{jt}}\right) \tag{13}$$

where an upper bar above a variable denotes a geometric mean; *Y* is real value-added; *L* is labour input (hours worked); *K* is the real capital stock. The lack of comparable cross-country data on employment and wages by education group at the industry-level, as well as the absence of industry-level data on the use and prices of different types of capital goods, limits our ability to control for factor quality. Therefore, the TFP measures that we construct capture variation in both technology and factor quality. The variable $\overline{\sigma}_{cjt} = 1/2.(\alpha_{cjt} + \overline{\alpha}_{jt})$ is the average of labour's share in value-added in country *c* ($\alpha_{cjt}$) and the geometric mean labour share ($\overline{\alpha}_{jt}$).

One problem in measuring TFP is that the observed share of labour in value-added is typically quite volatile. This suggests measurement error, and we therefore exploit the properties of the translog production function to smooth labour shares. Assuming the

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[15] See, for example, the discussion in Obstfeld and Rogoff (2000).

[16] See, for example, Caves *et al.* (1982a), (1982b) and Harrigan (1997).

production technology is translog, $\alpha_{cjt}$ may be expressed as the following function of the capital-labour ratio and a country-industry constant,

$$\alpha_{cjt} = \xi_{cj} + \phi_j . \ln\left(K_{cjt} / L_{cjt}\right) \tag{14}$$

If actual labour shares deviate from their true values by an i.i.d. measurement error term, the parameters of this equation can be estimated by fixed effects panel data estimation, where we allow the coefficient on the capital-labour ratio to vary across industries *j*. The fitted values from this equation are used as the labour cost shares in our calculation of relative TFP above.

It is well known that, even after smoothing labour shares, *measured* TFP remains pro-cyclical due for example to quasi-fixed factors, as discussed in Hall (1990). We wish to capture *'true'* TFP or technical efficiency after abstracting from the influence of business cycle fluctuations and short-run shocks. Therefore, we follow the real business cycle literature (see, for example, Hodrick and Prescott (1997) and Baxter and King (1999)) in smoothing measured TFP using a Hodrick-Prescott filter. The filter separates the growth and cyclical components of the data, and we employ the standard accepted value for the smoothing parameter λ from the real business cycle literature (λ=1600 using quarterly data, which corresponds to λ=6.25 using annual data).[17] Smoothing measured TFP in this way not only enables us to abstract from business cycle fluctuations and extract a measure of 'true' TFP, but also mitigates the concern that short-run shocks to the share of a sector in GDP may affect measured TFP. The inclusion of country-industry fixed effects in our econometric equation controls for unobserved heterogeneity across countries which affects both the share of a sector in GDP and measured TFP.

### 3.4 Measuring Factor Endowments

Our factor endowment variables include physical capital, land area, and labour disaggregated by both level of educational attainment and sex. Our measures of educational attainment are the number of men (women) out of the working age male (female) population

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[17] The value of 6.25 for annual data is taken from Ravn and Uhlig (2001). They show analytically that this corresponds exactly to the standard accepted value of 1600 for quarterly data. Baxter and King (1999) propose a similar value of 10 for annual data. The results that follow are robust to the use of alternative values for the smoothing parameter.

with various levels of educational attainment. We construct these measures from the detailed information on educational attainment in country labour force surveys, using standard definitions of low, medium and high education from the labour market literature. The use of detailed information from labour force surveys enables us to develop measures that are defined in as consistent a way as possible across countries and that are a considerable advance over existing cross-country data sources. We control for any remaining cross-country differences in the classification of educational attainment through the inclusion of country-industry fixed effects. These mean that the relationship between production structure and educational attainment is identified solely from within-country changes over time.

As documented below, there are substantial differences in the evolution of male and female educational attainment within countries over time, with further differences observed across countries. We use this variation to identify separately the male and female coefficients, and to examine empirically whether the effects of endowments of a given education level on production structure are the same for men and women.

The use of the *stock* of educated individuals of working age and the *stock* of physical capital as factor endowments limits the scope for shocks to the share of a sector in GDP to influence these variables. For an individual of age 40, the decision whether to enter secondary school was determined 30 years ago, and the decision whether to go to university was determined 20 years ago. The current stock of working age individuals with a particular level of educational attainment is determined by the educational decision of past cohorts in school, and as such is pre-determined with respect to current shocks to the share of a sector in GDP. Similarly, the current physical capital stock is determined by past investment decisions and is pre-determined with respect to shocks to GDP.

More formally, we assume that current factor endowment stocks are weakly exogenous with respect to current and future shocks to the shares of sectors in GDP, $cov(v_{ct}, \psi_{cjt+s}) = 0$ for all $s \geq 0$. As a robustness test, we also considered weaker assumptions where current and future shocks to the share of a sector in GDP are uncorrelated with factor endowment stocks in period $t\text{-}z$ and earlier, $cov(v_{ct}, \psi_{cjt+s}) = 0$ for all $s \geq z$. Under this assumption, factor endowments in period $t\text{-}z$ and earlier are valid instruments for current factor endowments. Re-estimating the model using information on lagged factor endowments yielded a very similar pattern of results. The inclusion of the country-industry fixed effects controls for unobserved heterogeneity across countries which affects both the share of a sector in GDP and factor endowments.

The estimated coefficients on factor endowments in equations (6) and (8) are *general equilibrium* effects. Even if countries have identical technologies and preferences, the existence of many goods ($n$) and factors of production ($m$) means that we cannot make predictions about the effect of individual factor endowments on the output of individual industries. Therefore, we should not necessarily expect a factor endowment to have a positive effect on the GDP share of one particular industry that uses that factor of production relatively intensively. Nevertheless, since with many goods and factors of production the theorems of the 2×2×2 Heckscher-Ohlin model hold in a weakened form as averages or correlations,[18] we should expect a pattern of estimated coefficients across all industries as a whole that is broadly consistent with information on factor intensity.

**3.5 Measurement Error**

One final econometric concern is that our measures of relative prices, TFP and factor endowments may be subject to measurement error. This may be a particular concern for the non-manufacturing sectors, and we therefore employ a number of controls for potential measurement error. First, TFP for each country-industry-time observation is measured relative to a common reference point (the industry-time geometric mean). Therefore, any error in measuring TFP that is common across countries for a particular industry-time observation will be controlled for.

Second, when linear homogeneity is imposed in equations (6) and (8), TFP and prices in each country-industry are normalized by the manufacturing values for that country. Any error in measuring TFP or prices that is common across industries for a particular country-time observation will, therefore, also be controlled for. Third, the country-industry fixed effect included in the econometric estimation will control for any time-invariant errors of measurement for an industry in a particular country. Fourth, the industry-time dummies included in the econometric estimation will capture any errors of measurement that are common across countries for a particular industry-time observation.

[18] See, for example, the discussion in Dixit and Norman (1980), Chapter 4 and Ethier (1984).

Finally, any remaining classical measurement error will attenuate the estimated parameters of interest towards zero, biasing the results away from the economic relationships that we seek to identify. The potential objection that measurement error may be greater for non-manufacturing sectors must also be counterbalanced against the fact that manufacturing is typically less than 30% of GDP in OECD countries, and there is a need to understand the remaining 70% of economic activity. The dataset that we employ is a later version of that used to analyse productivity convergence by Bernard and Jones (1996), who find important differences in the extent of convergence in productivity between manufacturing and non-manufacturing industries.

## 4. Data Description and Analysis

The main source of data in the empirical application is the OECD's International Sectoral Data Base (ISDB), which provides information for one-digit manufacturing and non-manufacturing industries on current price value-added, constant price value-added, employment, hours worked and the real physical capital stock. Data on GDP and a country's aggregate endowment of physical capital are also obtained from the ISDB. As discussed above, information on educational endowments comes from individual countries' labour force surveys, while data on arable land area are collected from the United Nations Food and Agricultural Organisation (FAO).[19]

Our sample is an unbalanced panel of 14 OECD countries and five one-digit industries during the period 1975-94. The distribution of observations across countries and over time is given in Table 1A, and we are careful to examine the robustness of the results to alternative estimation samples. Table 1B lists the five one-digit industries, together with a sixth industry 'Government Producers and Other Producers.' We focus in our analysis on the five market sectors. Since all coefficients vary across industries, the model is estimated separately by industry. The implied effect of relative prices, technology and endowments on the government sector can be obtained from the cross-equation restrictions implied by the theory. More detailed information on the disaggregated sectors included in each one-digit industry is given in Appendix B.

[19] See Appendix B for further information concerning the data sets used.

Table 2 reports the evolution of industry shares of GDP over time in each of the 14 countries. The sample period was characterised by a decline in the share of Agriculture in GDP in all countries, although the rate of decline varies markedly – from over 95% in Germany during 1975-93 to less than 30% in the Netherlands during 1975-94.

Countries differ substantially in terms of the initial share of manufacturing. In Germany and Japan, manufacturing constituted about 30% of GDP in 1975, while, in Australia, Canada, and Denmark, it was responsible for only 20% of GDP. All countries experienced a decline in manufacturing's share over time, but the magnitude and timing of this decline again varies markedly. In Australia and the United Kingdom, manufacturing's share of GDP declined by approximately 35% over the whole sample period, while, in Denmark and Finland, it fell by less than 10%. In the Netherlands and Norway, the decline was most rapid in the first half of the sample period, whereas, in Germany and Japan, most of the fall in manufacturing's share of GDP occurred in the second half of the sample period. In other countries, such as Italy and the United Kingdom, the rate of decline of manufacturing's share of GDP was roughly constant over time.

The initial level of the share of Other Production in GDP varies from about 10% in Germany and the United States to over 15% in the natural resource rich countries of Australia and Canada. In all countries except Norway and Japan, the share of this sector in GDP declined during 1975-94. The share of Business Services in GDP rose in all countries for which data are available during 1975-94.[20] The increase was most rapid in Australia, the Netherlands, Sweden, and the United Kingdom, and was least rapid in Denmark and Norway. The share of Other Services in GDP rose in all countries except Denmark and Norway.

Table 3 reports male and female educational attainment as a percentage of the male and female population respectively for the years 1975, 1985 and 1994. Data for 1975 are only available for half of the 14 countries, and, therefore, the discussion here concentrates on the period 1985-94. Taking men and women together, it is well known that this period was characterised by rising educational attainment in the OECD.[21] Nonetheless, the rate of

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[20] For Belgium, Germany, and Italy, the data are for a sub-sector of Business Services: Financial Institutions and Insurance (ISIC 80).

[21] See, for example, Nickell and Bell (1995), (1996), Berman *et al.* (1998) and Machin and Van Reenen (1998).

increase varies markedly across countries: from 38% and 36% in Italy and the Netherlands during 1985-94, to 14% and 15% in Denmark and the United States during the same period.[22]

Breaking out men and women separately, there is further variation both within and across countries. The increase over time in the share of the population with high education is typically largest for women. In Australia in 1982 and Canada in 1975, the share of women with high education was just over half the value for men. By 1993 in Australia and 1994 in Canada, the share of women with high education had reached over 75% of the value for men. However, the heterogeneity in experiences across countries is evident from Japan, where the share of women with high education in 1994 remained about 30% of the value for men.

Multiplying the percentage shares in Table 3 by the male and female population levels reported in Table 4, we obtain our measure of countries' endowments of men and women with each education level. Table B1 of Appendix B shows that not only do educational endowments vary substantially across countries and over time, but there is also a large degree of variation in the intensity with which the five one-digit industries employ men of a given educational level relative to women of the same educational level. This variation in factor intensity suggests that we should expect different general equilibrium effects on industrial structure from changes in male and female educational endowments. Information on endowments of physical capital and arable land is also reported in Table 4. There is also much variation in the relative abundance of these two factor endowments across countries and over time. While the physical capital stock rose by 113% in Japan during 1975-92, Denmark saw a rise of 34% during the same period.

[22] The aggregate educational attainment data (for men and women together) are not reported in Table 3, but are a weighted average of those reported for men and women separately.

**Table 1A: Estimation sample by Country (observations on the 5 one-digit industries listed in Table 1B)**

| Country | Period |
|---|---|
| 1. Australia | 1983-93 |
| 2. Belgium | 1987-94 |
| 3. Canada | 1976-92 |
| 4. Denmark | 1984-92 |
| 5. Finland | 1985-94 |
| 6. France | 1983-92 |
| 7. West Germany | 1985-93 |
| 8. Italy | 1978-94 |
| 9. Japan | 1976-94 |
| 10. Netherlands | 1976-94 |
| 11. Norway | 1976-91 |
| 12. Sweden | 1976-94 |
| 13. United Kingdom | 1976-93 |
| 14. United States | 1976-93 |

**Table 1B: Industry Composition (International Standard Industrial Classification (ISIC))**

| Industry | Industry Code | Further Details |
|---|---|---|
| 1. Agriculture | 10 | Agriculture, Hunting, Forestry and Fishing (ISIC 10) |
| 2. Manufacturing | 30 | Manufacturing (ISIC 30) |
| 3. Other Production | 40 | Mining and Quarrying (ISIC 20)<br>Electricity, Gas, and Water (ISIC 40)<br>Construction (ISIC 50) |
| 4. Other Services | 50 | Wholesale and Retail Trade, Restaurants and Hotels (ISIC 60)<br>Transport, Storage, and Communication (ISIC 70)<br>Community, Social, and Personal Services (ISIC 90) |
| 5. Business Services | 60 | Financial Institutions and Insurance (ISIC 82)<br>Real Estate and Business Services (ISIC 83) |
| Excluded industry: Government/Other Producers | 70 | Producers of Government Services<br>Other Producers |

**Notes:** see Appendix B for detailed information on the disaggregated sectors included in each one-digit industry above.

**Table 2: Shares of Industrial Sectors in a Country's GDP (per cent)[(a)]**

| Country | Year | Agric | Manuf | Other Prod. | Business Services | Other Services | Gov./ Other |
|---|---|---|---|---|---|---|---|
| Australia | 1975 | 4.96 | 20.35 | 15.90 | 15.14 | 39.02 | 4.63 |
| | 1985 | 3.94 | 16.94 | 16.81 | 18.68 | 39.59 | 4.04 |
| | 1994 | 2.76 | 14.25 | 12.78 | 24.51 | 42.08 | 3.62 |
| Belgium | 1975 | 2.92 | 25.91 | 12.84 | 3.44 [(a)] | 39.39 | 15.50 |
| | 1985 | 2.32 | 22.67 | 10.30 | 5.76 [(a)] | 44.01 | 14.94 |
| | 1994 | 1.57 | 19.70 | 9.75 | 5.45 [(a)] | 50.09 | 13.44 |
| Canada | 1975 | 4.91 | 20.35 | 15.01 | 15.28 | 26.14 | 18.31 |
| | 1985 | 3.10 | 18.96 | 15.77 | 18.22 | 25.78 | 18.17 |
| | 1992 | 2.38 | 16.26 | 12.77 | 21.29 | 26.94 | 20.36 |
| Denmark | 1975 | 5.59 | 19.99 | 10.21 | 14.58 | 29.19 | 20.44 |
| | 1985 | 5.60 | 19.57 | 8.15 | 16.76 | 27.83 | 22.09 |
| | 1992 | 3.86 | 18.53 | 8.60 | 17.95 | 28.36 | 22.70 |
| Finland | 1975 | 10.54 | 26.05 | 14.06 | 12.69 | 21.38 | 15.28 |
| | 1985 | 8.06 | 25.09 | 10.92 | 14.37 | 22.95 | 18.61 |
| | 1994 | 5.47 | 24.42 | 8.13 | 18.82 | 22.23 | 20.93 |
| France | 1975 | 5.60 | 27.22 | 10.36 | 15.95 | 25.55 | 15.32 |
| | 1985 | 4.07 | 23.07 | 8.95 | 19.23 | 26.92 | 17.76 |
| | 1992 | 2.93 | 20.80 | 8.33 | 22.83 | 28.11 | 17.00 |
| West Germany | 1975 | 2.88 | 35.40 | 10.10 | 4.64 [(a)] | 26.28 | 14.32 |
| | 1985 | 1.80 | 32.62 | 9.09 | 5.66 [(a)] | 29.33 | 14.09 |
| | 1993 | 1.09 | 27.16 | 8.32 | 6.04 [(a)] | 35.67 | 13.68 |
| Italy | 1975 | 7.14 | 27.43 | 13.59 | 5.11 [(b)] | 35.48 | 11.25 |
| | 1985 | 4.55 | 24.61 | 11.08 | 4.79 [(b)] | 41.86 | 13.11 |
| | 1994 | 2.94 | 20.52 | 11.16 | 4.99 [(b)] | 46.82 | 13.57 |
| Japan | 1975 | 5.28 | 29.05 | 11.74 | 12.93 | 16.73 [(c)] | 10.05 |
| | 1985 | 3.06 | 28.37 | 10.98 | 14.78 | 20.22 [(c)] | 9.74 |
| | 1994 | 2.05 | 23.49 | 13.25 | 17.17 | 22.21 [(c)] | 9.64 |
| Netherl. | 1975 | 4.72 | 22.69 | 13.38 | 13.73 | 31.08 | 14.40 |
| | 1985 | 4.15 | 18.64 | 15.50 | 18.29 | 31.20 | 12.22 |
| | 1994 | 3.52 | 18.63 | 9.64 | 24.10 | 33.37 | 10.74 |
| Norway | 1975 | 5.01 | 21.81 | 12.21 | 14.32 | 30.99 | 15.66 |
| | 1985 | 3.30 | 13.69 | 27.35 | 15.22 | 25.45 | 14.99 |
| | 1991 | 3.14 | 12.14 | 20.49 | 18.23 | 28.74 | 17.26 |
| Sweden | 1975 | 4.84 | 28.02 | 10.25 | 14.40 | 21.37 | 21.12 |
| | 1985 | 3.59 | 23.66 | 9.81 | 17.58 | 21.21 | 24.15 |
| | 1994 | 2.16 | 21.44 | 8.56 | 23.33 | 21.53 | 22.98 |
| United Kingdom | 1975 | 2.58 | 28.21 | 11.33 | 15.71 | 24.73 | 17.44 |
| | 1985 | 1.90 | 23.92 | 15.36 | 18.80 | 24.24 | 15.78 |
| | 1993 | 1.88 | 19.94 | 9.76 | 24.54 | 28.69 | 15.19 |
| United States | 1975 | 3.46 | 22.28 | 10.07 | 18.21 | 31.68 | 14.30 |
| | 1985 | 2.07 | 19.47 | 10.78 | 23.08 | 31.85 | 12.75 |
| | 1993 | 1.65 | 17.39 | 8.08 | 26.74 | 33.05 | 13.09 |

**Notes:** 'Government and Other Producers' (ISIC 70) is the excluded industry in the econometric analysis that follows. [(a)] Figures are for the sub-sector 'Financial Institutions and Insurance' (ISIC 82), and the numbers therefore sum to less than 100%. [(b)] Figures are for the sub-sector 'Financial Institutions and Insurance (ISIC 82). [(c)] Figures for 'Other Services' exclude the sub-sector 'Wholesale and Retail Trade, Restaurants and Hotels' (ISIC 60), and therefore the numbers sum to less than 100%. Source: OECD International Sectoral Database (ISDB). See Appendix B for more information concerning the data used.

**Table 3: Education attainment as a Percentage of the Male and Female Working Age Populations (1975, 1985, and 1994)**

| | | Men | | | Women | | |
|---|---|---|---|---|---|---|---|
| **Country** | **Year** | **Low** | **Med** | **High** | **Low** | **Med** | **High** |
| Australia | 1982 | .484 | .438 | .078 | .623 | .333 | .044 |
| | 1985 | .462 | .448 | .091 | .592 | .353 | .055 |
| | 1993 | .341 | .542 | .117 | .441 | .469 | .090 |
| Belgium | 1975 | - | - | - | - | - | - |
| | 1986 | .349 | .600 | .051 | .457 | .523 | .021 |
| | 1994 | .277 | .649 | .073 | .350 | .614 | .035 |
| Canada | 1975 | .272 | .639 | .089 | .264 | .687 | .049 |
| | 1985 | .198 | .682 | .120 | .189 | .727 | .084 |
| | 1994 | .127 | .696 | .147 | .133 | .723 | .118 |
| Denmark | 1983 | .337 | .611 | .053 | .452 | .531 | .017 |
| | 1985 | .240 | .707 | .053 | .386 | .595 | .019 |
| | 1994 | .190 | .751 | .055 | .302 | .665 | .028 |
| Finland | 1984 | .526 | .387 | .086 | .562 | .359 | .079 |
| | 1985 | .512 | .399 | .089 | .547 | .370 | .082 |
| | 1994 | .438 | .440 | .121 | .440 | .435 | .125 |
| France | 1982 | .469 | .421 | .109 | .466 | .405 | .129 |
| | 1985 | .425 | .449 | .125 | .418 | .436 | .146 |
| | 1994 | .307 | .511 | .181 | .308 | .485 | .207 |
| West Germany | 1984 | .148 | .783 | .109 | .315 | .647 | .051 |
| | 1985 | .143 | .774 | .121 | .311 | .644 | .057 |
| | 1994 | .132 | .758 | .140 | .252 | .681 | .083 |
| Italy | 1979 | .529 | .426 | .044 | .474 | .477 | .049 |
| | 1985 | .392 | .550 | .058 | .330 | .607 | .063 |
| | 1994 | .217 | .715 | .083 | .172 | .744 | .094 |
| Japan | 1975 | .433 | .425 | .142 | .484 | .487 | .029 |
| | 1985 | .306 | .501 | .193 | .336 | .619 | .045 |
| | 1994 | .228 | .534 | .238 | .226 | .703 | .071 |
| Netherlands | 1975 | .371 | .526 | .103 | .490 | .460 | .050 |
| | 1985 | .216 | .630 | .153 | .278 | .621 | .100 |
| | 1994 | .146 | .648 | .206 | .169 | .671 | .160 |
| Norway | 1976 | .023 | .862 | .114 | .018 | .915 | .067 |
| | 1985 | .030 | .822 | .147 | .025 | .869 | .106 |
| | 1994 | .029 | .775 | .195 | .028 | .803 | .169 |
| Sweden | 1975 | .553 | .323 | .123 | .596 | .301 | .103 |
| | 1985 | .410 | .413 | .177 | .420 | .398 | .181 |
| | 1994 | .293 | .430 | .203 | .262 | .443 | .227 |
| United Kingdom | 1975 | .514 | .438 | .048 | .634 | .352 | .015 |
| | 1985 | .375 | .528 | .097 | .447 | .508 | .046 |
| | 1994 | .258 | .618 | .124 | .314 | .613 | .073 |
| United States | 1975 | .274 | .549 | .177 | .229 | .625 | .146 |
| | 1985 | .166 | .598 | .237 | .122 | .672 | .206 |
| | 1994 | .117 | .605 | .270 | .083 | .659 | .257 |

**Notes:** educational attainment data are from individual-level information in country labour force surveys. Low corresponds to no education or primary education; Medium corresponds to secondary and/or vocational qualifications; High corresponds to college degree or equivalent. See Appendix B for further information concerning the data used.

**Table 4: Endowments of Physical Capital (billions US dollars, 1990 prices), Population (thousands), and Arable Land Area (thousands of hectares)**

| Country | Year | Capital | Male Pop. | Female Pop. | Arable |
|---|---|---|---|---|---|
| Australia | 1979 | 789.80 | 4777 | 4651 | 43932 |
| | 1985 | 971.04 | 5294 | 5148 | 47150 |
| | 1993 | 1226.92 | 5944 | 5828 | 46300 |
| Belgium | 1975 | 385.88 | - | - | 982 |
| | 1986 | 536.11 | 3338 | 3312 | 765 |
| | 1994 | 671.63 | 3378 | 3325 | 777 |
| Canada | 1975 | 1123.04 | 7649 | 7531 | 44000 |
| | 1985 | 1686.04 | 8946 | 8827 | 45900 |
| | 1992 | 2192.23 | 9756 | 9609 | 45370 |
| Denmark | 1983 | 374.89 | 1702 | 1673 | 2593 |
| | 1985 | 389.32 | 1716 | 1683 | 2601 |
| | 1992 | 441.74 | 1768 | 1721 | 2539 |
| Finland | 1984 | 353.87 | 1663 | 1663 | 2294 |
| | 1985 | 365.18 | 1672 | 1667 | 2276 |
| | 1994 | 457.47 | 1719 | 1685 | 2267 |
| France | 1982 | 2419.60 | 17674 | 17611 | 17651 |
| | 1985 | 2573.97 | 18181 | 18224 | 17923 |
| | 1992 | 3061.88 | 18797 | 18839 | 18046 |
| West Germany | 1984 | 3756.45 | 21259 | 21396 | 11952 |
| | 1985 | 3845.38 | 21355 | 21385 | 11957 |
| | 1993 | 4716.85 | 28117 | 27127 | 11676 |
| Italy | 1977 | 2380.55 | 17800 | 18645 | 9359 |
| | 1985 | 3054.87 | 19313 | 19973 | 9050 |
| | 1994 | 3911.39 | 19353 | 19607 | 8329 |
| Japan | 1975 | 2757.52 | 37180 | 38460 | 4460 |
| | 1985 | 5276.81 | 40950 | 41360 | 4209 |
| | 1994 | 8572.96 | 43630 | 43360 | 3999 |
| Netherlands | 1975 | 583.50 | 4406 | 4322 | 759 |
| | 1985 | 732.83 | 5023 | 4899 | 826 |
| | 1994 | 886.90 | 5182 | 5353 | 885 |
| Norway | 1975 | 203.16 | 1266 | 1239 | 792 |
| | 1985 | 319.33 | 1355 | 1314 | 858 |
| | 1991 | 376.38 | 1403 | 1355 | 892 |
| Sweden | 1975 | 414.12 | 2660 | 2599 | 3006 |
| | 1985 | 532.66 | 2729 | 2665 | 2922 |
| | 1994 | 669.49 | 2844 | 2754 | 2780 |
| United Kingdom | 1975 | 1970.63 | 17554 | 17638 | 6883 |
| | 1985 | 2464.50 | 18643 | 18555 | 7006 |
| | 1993 | 3063.79 | 19019 | 18763 | 6081 |
| United States | 1975 | 13658.82 | 68335 | 70560 | 186472 |
| | 1985 | 18257.51 | 78450 | 80067 | 187765 |
| | 1993 | 22083.93 | 83768 | 84837 | 181950 |

**Notes:** capital is stock of real physical capital from OECD's International Sectoral Database (ISDB) (billions of 1990 US dollars). Male and Female Population data from individual country labour force surveys (thousands). Arable is arable land area from United Nations Food and Agricultural Organisation (FAO) (thousands of hectares). See Appendix B for further information concerning the data used.

## 5. Econometric Estimation

### 5.1. Baseline Specification

We begin by considering the static long-run relationship between the share of a sector in GDP, relative prices, technology and factor endowments in equation (6). As reported in Table C1 of Appendix C, the majority of industry GDP shares and independent variables are I(1) during the sample period according to both the Levin and Lin (1992) and Maddala and Wu (1999) panel data unit root tests. Columns (1)-(5) of Table 5 present the results of estimating equation (6) for Agriculture, Manufacturing, Other Production, Other Services and Business Services using the within groups (fixed effects) estimator. As reported in the lower panel of the table, we reject the null hypothesis of a unit root in the residuals in the vast majority of cases with either the Levin and Lin or Maddala and Wu panel data tests. This finding that the residuals are I(0) provides support for the cointegrating interpretation given above.

The pattern of estimated coefficients on the relative price and TFP terms in Table 5 is consistent with the predictions of theory. In all 5 industries, the estimated own-industry price terms are positive and statistically significant at the 5% level (imposing linear homogeneity means that, in Manufacturing, the own-industry estimated coefficient is minus the sum of the estimated coefficients on the other industry terms). With the exception of Other Services, the estimated coefficients on the own-industry TFP terms are positive and statistically significant at conventional critical values (in Manufacturing, the own-industry effect is again minus the sum of the estimated effects on the other industry terms).

We noted earlier that, if industry trade barriers differ across countries by a constant, the relative price terms can be replaced by a country-industry fixed effect and industry-time dummies. However, an F-test of the null hypothesis that the estimated coefficients on the relative price terms are zero is rejected at the 5% level in all industries. This provides evidence of the importance of controlling for country-specific changes in industry relative prices over time, as in our econometric specification.

We find statistically significant effects of factor endowments on patterns of production. The coefficients on individual endowments vary substantially across industries. For example, while endowments of low education men have a positive and statistically significant effect on the share of Agriculture and Other Services, the effect in Manufacturing and Business Services is negative with the Manufacturing coefficient significant at the 12%

level. The coefficients themselves have a direct economic interpretation. For example, doubling an economy's endowments of low education men relative to physical capital (a large change in relative factor endowments compared to the sample standard deviation) implies an increase in the share of Agriculture in GDP by 3.6 percentage points. We provide further economic interpretation for the pattern of estimation results below by decomposing the change in the shares of sectors in GDP during the sample period into the contribution of individual explanatory variables.

Male and female educational endowments have very different implications for patterns of production. For example, while endowments of medium education men have a negative and statistically significant effect on the share of business services in GDP, the effect of endowments of medium education women is positive and statistically significant. The null hypothesis that the estimated coefficients on all male educational endowments equal those on female educational endowments is rejected at the 5% level in all industries except Manufacturing. This provides support for the idea that men and women of the same educational level differ or are perceived to differ in terms of other characteristics and dimensions of human capital.

### 5.2. Instrumental Variables Estimates

In Table 6, we examine the potential endogeneity of our measures of relative prices. The specification in equation (6) is re-estimated using Instrumental Variables. Our instruments for relative prices are: prices at the border, exchange rates and average tariff rates (as described in more detail in Section 3). The instruments are highly statistically significant in the first stage-regression for relative prices. The lower panel of Table 6 reports *p*-values for an F-test of the null hypothesis that the coefficients on the three instruments are equal to zero in the first-stage. In all cases, the null hypothesis is rejected at conventional critical values.

We examine the validity of the assumption that shocks to shares of sectors in domestic GDP do not affect world prices at the border, exchange rates and average tariff rates with a Sargan test of the model's overidentifying restrictions. In all industries, we are unable to reject the null hypothesis that the instruments are uncorrelated with the residuals in the second-stage regression for GDP shares.

In general, the Instrumental Variables coefficients lie close to those estimated in Table 5 using within groups. The lower panel of Table 6 also reports the results of a Hausman test of the null hypothesis that the within groups estimator is consistent. In each industry, we are unable to reject the null hypothesis at conventional critical values.

Taken together, these three sets of diagnostic tests provide evidence that the within groups estimates are not substantially biased by the potential endogeneity of relative prices, and in the remainder of the paper we focus on the within groups results.

### 5.3. Dynamic Specification

In practice, it is likely to take time for factors of production to be reallocated from declining to expanding sectors. Equation (6) should therefore be interpreted as a long-run relationship towards which gradual adjustment occurs. The speed at which factors of production are able to be reallocated will depend on labour market policies and institutions – in particular, on employment protection provisions that limit the ability of firms in declining sectors to shed labour or raise the cost of them doing so.

Table 7 augments equation (6) with a lagged dependent variable and with the lagged dependent variable interacted with countries' ranking in terms of employment protection. We thus arrive at the dynamic specification in equation (8), where the speed of adjustment towards long-run equilibrium is given by $(1-\delta_0-(\delta_1 \times EmProt_c))$. For convenience, the employment protection ranking is normalized by its mean across countries; this normalization implies that one minus the estimated coefficient on the lagged dependent variable $(1-\delta_0)$ can be interpreted as a measure of the speed of adjustment at sample mean values of employment protection.

The estimated coefficient on the lagged dependent variable in Table 7 is positive and highly statistically significant in all industries, providing evidence of partial adjustment. The employment protection interaction is positively signed and statistically significant in the 3 industries that declined as a share of GDP during the sample period – Agriculture, Manufacturing and Other Production. This provides evidence that countries with higher levels of employment protection were slower to reallocate resources away from these sectors in response to a change in long-run patterns of specialization. The employment protection interaction is positively signed although not statistically significant in the 2 industries which expanded as a share of GDP during the sample period – Other Services and Business Services. This is consistent with the idea that the main effect of employment protection is to raise the cost of shedding labour in declining sectors.

The effects of employment protection are not only statistically significant but also quantitatively important. Moving from the country with the lowest levels of employment protection (the United States) to the country with the highest (Italy) raises the estimated coefficient on the lagged dependent variable in Manufacturing from 0.44 to 0.78, and reduces the implied speed of adjustment from 0.56 to 0.22.

As a robustness test, we estimated an alternative specification with a full set of interactions between country dummies and the lagged dependent variable. This produced a similar pattern of results. The countries with large estimated coefficients on the lagged dependent variable were those with high levels of employment protection.[23] We also examined the robustness of the results to alternative estimation samples, excluding each country sequentially from the sample. In all cases, the new estimated coefficients lay within the 95% confidence interval around those reported in Table 7.

[23] To compare the two sets of estimates, we recorded the estimated coefficients on the country dummies interacted with the lagged dependent variable, as well as the estimated coefficient on the employment protection interaction multiplied by the value of employment protection. Pooling across countries and industries, and regressing the first set of estimates on the second yields an estimated coefficient that is both highly statistically significant and close to one (the coefficient (*standard error*) were 1.34 (*0.34*)), providing support for our more parsimonious specification.

**Table 5: Baseline Within Groups Estimation**

| GDP $share_{cjt}$ | (1) Agriculture | (2) Manufact. | (3) Other Production | (4) Other Services | (5) Business Services |
|---|---|---|---|---|---|
| Obs | 200 | 200 | 200 | 200 | 200 |
| Years | 1976-94 | 1976-94 | 1976-94 | 1976-94 | 1976-94 |
| $Mskill1_{ct}$ ($\gamma_1$) | 0.0355 | -0.0290 | 0.0016 | 0.0358 | -0.0129 |
| | *(5.55)* | *(-1.55)* | *(0.09)* | *(2.30)* | *(-1.07)* |
| $Mskill2_{ct}$ ($\gamma_2$) | -0.0034 | -0.0215 | -0.0921 | 0.1356 | -0.0809 |
| | *(-0.25)* | *(-0.83)* | *(-2.65)* | *(4.55)* | *(-3.72)* |
| $Mskill3_{ct}$ ($\gamma_3$) | -0.0013 | -0.0268 | 0.0249 | 0.0254 | -0.0116 |
| | *(-0.19)* | *(-1.40)* | *(1.33)* | *(1.80)* | *(-0.74)* |
| $Fskill1_{ct}$ ($\gamma_4$) | -0.0378 | 0.0126 | 0.0150 | -0.0290 | -0.0003 |
| | *(-5.37)* | *(0.65)* | *(0.73)* | *(-1.76)* | *(-0.02)* |
| $Fskill2_{ct}$ ($\gamma_5$) | 0.0036 | 0.0081 | 0.0420 | -0.0383 | 0.0610 |
| | *(0.36)* | *(0.32)* | *(1.47)* | *(-1.60)* | *(3.35)* |
| $Fskill3_{ct}$ ($\gamma_6$) | 0.0100 | 0.0070 | -0.0448 | -0.0007 | 0.0116 |
| | *(2.17)* | *(0.49)* | *(-3.10)* | *(-0.07)* | *(1.06)* |
| $Arable_{ct}$ ($\gamma_7$) | -0.0045 | 0.0204 | 0.0300 | -0.1082 | 0.0140 |
| | *(-0.71)* | *(0.93)* | *(1.21)* | *(-4.76)* | *(1.12)* |
| $P10_{ct}$ ($\alpha_1$) | 0.0275 | 0.0057 | -0.0360 | 0.0138 | 0.0065 |
| | *(12.63)* | *(0.88)* | *(-2.97)* | *(1.87)* | *(1.16)* |
| $P40_{ct}$ ($\alpha_2$) | -0.0088 | -0.0510 | 0.1277 | -0.0241 | -0.0262 |
| | *(-3.87)* | *(-7.61)* | *(10.22)* | *(-2.95)* | *(-5.75)* |
| $P50_{ct}$ ($\alpha_3$) | -0.0053 | 0.0101 | -0.0343 | 0.0571 | -0.0716 |
| | *(-1.07)* | *(0.66)* | *(-1.78)* | *(3.65)* | *(-7.30)* |
| $P60_{ct}$ ($\alpha_4$) | 0.0046 | -0.0446 | -0.0091 | -0.0481 | 0.1079 |
| | *(1.43)* | *(-3.35)* | *(-0.77)* | *(-3.99)* | *(13.65)* |
| $TFP10_{ct}$ ($\beta_1$) | 0.0220 | -0.0058 | 0.0041 | -0.0162 | 0.0103 |
| | *(8.58)* | *(-0.84)* | *(0.27)* | *(-1.64)* | *(1.49)* |
| $TFP40_{ct}$ ($\beta_2$) | 0.0029 | -0.0374 | 0.0849 | -0.0188 | -0.0190 |
| | *(0.826)* | *(-4.36)* | *(4.97)* | *(-1.72)* | *(-2.21)* |
| $TFP50_{ct}$ ($\beta_3$) | 0.0066 | 0.0588 | -0.0625 | -0.0041 | 0.0018 |
| | *(1.32)* | *(3.06)* | *(-3.74)* | *(-0.33)* | *(0.19)* |
| $TFP60_{ct}$ ($\beta_4$) | 0.0088 | -0.0421 | 0.0066 | 0.0432 | 0.0199 |
| | *(1.66)* | *(-2.00)* | *(0.38)* | *(2.98)* | *(1.77)* |
| Year Dummies | yes | Yes | yes | yes | yes |
| Country-Industry Fixed effect | yes | Yes | yes | yes | yes |
| Maddala-Wu *(p-value)* | 0.000 | 0.000 | 0.000 | 0.000 | 0.015 |
| Levin-Lin *(unit root t-statistic)* | -8.311 | -7.720 | -4.462 | -6.318 | -6.163 |
| Adjusted $R^2$ | 0.9764 | 0.9807 | 0.9654 | 0.9955 | 0.9945 |

**Notes:** Asymptotic t-statistics in parentheses (based on Huber-White heteroscedasticity robust standard errors). Regressions are estimated industry-by-industry, pooling observations across countries and over time. Estimation is by within groups (least squares dummy variables). All specifications include country-industry fixed effects and full set of industry-year dummies. Dependent variable is share of a sector in a country's GDP. Independent variables: Mskill1 is log number of males out of working age male population with low education relative to stock of physical capital; Mskill2 is log number of males with medium education relative to physical capital; Mskill3 is log number of males with high education relative to physical capital; Fskill1-Fskill3 are female educational endowments defined analogously; Arable is log arable land area relative to physical capital; P10 is log price of industry 10 output (Agriculture) relative to industry 30 output (Manufacturing), and so on for the other industries; industry 40 is Other Production; industry 50 is Other Services; industry 60 is Business Services; TFP10 is a log superlative index number measure of TFP in industry 10 relative to TFP in industry 30, and so on for the other industries; to abstract from short-run fluctuations all TFP measures are smoothed with a Hodrick-Prescott filter; Maddala-Wu is the Maddala and Wu (1999) panel data test of the null hypothesis that there is a unit root in the residuals. Levin-Lin is the Levin and Lin (1992) panel data test of the null hypothesis that there is a unit root in the residuals. Critical values are from Levin and Lin (1992), Table 5: 1% critical value = -6.72; 5% critical value = -6.28; 10% critical value = -6.04.

## Table 6: Instrumental Variables Estimation

| **GDP share$_{cjt}$** | **(1) Agriculture** | **(2) Manufact.** | **(3) Other Production** | **(4) Other Services** | **(5) Business Services** |
|---|---|---|---|---|---|
| Obs | 200 | 200 | 200 | 200 | 200 |
| Years | 1976-94 | 1976-94 | 1976-94 | 1976-94 | 1976-94 |
| Mskill1$_{ct}$ ($\gamma_1$) | 0.0453 | -0.0269 | 0.0227 | 0.0257 | -0.0100 |
| | *(5.08)* | *(-0.96)* | *(0.75)* | *(1.07)* | *(-0.65)* |
| Mskill2$_{ct}$ ($\gamma_2$) | 0.0034 | -0.0223 | -0.0823 | 0.1248 | -0.0754 |
| | *(0.22)* | *(-0.52)* | *(-1.72)* | *(3.14)* | *(-3.12)* |
| Mskill3$_{ct}$ ($\gamma_3$) | 0.0021 | -0.0068 | 0.0530 | 0.0015 | -0.014 |
| | *(0.20)* | *(-0.25)* | *(1.87)* | *(0.07)* | *(-0.74)* |
| Fskill1$_{ct}$ ($\gamma_4$) | -0.0493 | 0.0066 | -0.0041 | -0.0182 | -0.0070 |
| | *(-4.96)* | *(0.20)* | *(-0.12)* | *(-0.65)* | *(-0.41)* |
| Fskill2$_{ct}$ ($\gamma_5$) | -0.0026 | -0.0258 | 0.0207 | -0.0172 | 0.0550 |
| | *(-0.20)* | *(-0.53)* | *(0.58)* | *(-0.49)* | *(2.37)* |
| Fskill3$_{ct}$ ($\gamma_6$) | 0.0098 | 0.0220 | -0.0456 | 0.0001 | 0.0139 |
| | *(1.712)* | *(0.96)* | *(-1.92)* | *(0.01)* | *(1.09)* |
| Arable$_{ct}$ ($\gamma_7$) | -0.0158 | 0.0721 | 0.0562 | -0.1465 | 0.0029 |
| | *(-0.28)* | *(1.38)* | *(0.97)* | *(-3.23)* | *(0.11)* |
| P10$_{ct}$ ($\alpha_1$) | 0.0354 | -0.0014 | 0.0294 | -0.0279 | -0.0118 |
| | *(5.23)* | *(-0.05)* | *(1.13)* | *(-1.37)* | *(-0.89)* |
| P40$_{ct}$ ($\alpha_2$) | -0.0092 | -0.1055 | 0.0953 | 0.0239 | -0.0289 |
| | *(-1.06)* | *(-2.50)* | *(2.70)* | *(0.89)* | *(-1.58)* |
| P50$_{ct}$ ($\alpha_3$) | -0.0234 | 0.1222 | 0.0388 | -0.0449 | -0.0924 |
| | *(-1.35)* | *(1.43)* | *(0.50)* | *(-0.75)* | *(-2.30)* |
| P60$_{ct}$ ($\alpha_4$) | 0.0256 | 0.0123 | 0.0019 | -0.0396 | 0.1335 |
| | *(1.52)* | *(0.24)* | *(0.04)* | *(-0.93)* | *(4.18)* |
| TFP10$_{ct}$ ($\beta_1$) | 0.0206 | -0.0177 | 0.0329 | -0.0372 | -0.0045 |
| | *(4.16)* | *(-0.96)* | *(1.36)* | *(-2.23)* | *(-0.37)* |
| TFP40$_{ct}$ ($\beta_2$) | 0.0041 | -0.0582 | 0.0668 | 0.0002 | -0.0152 |
| | *(0.81)* | *(-2.59)* | *(2.06)* | *(0.01)* | *(-1.11)* |
| TFP50$_{ct}$ ($\beta_3$) | -0.0018 | 0.1274 | 0.0013 | -0.0780 | -0.0156 |
| | *(-0.16)* | *(2.18)* | *(0.03)* | *(-2.22)* | *(-0.62)* |
| TFP60$_{ct}$ ($\beta_4$) | 0.0252 | 0.0262 | 0.0165 | 0.0421 | 0.0450 |
| | *(1.45)* | *(0.48)* | *(0.28)* | *(0.95)* | *(1.30)* |
| Year Dummies | yes | Yes | yes | yes | yes |
| Country-Industry Fixed Effect | yes | Yes | yes | yes | yes |
| First-Stage F-test *(p-value)* | 0.000 | - | 0.000 | 0.000 | 0.001 |
| Hausman *(p-value)* | 0.999 | 0.999 | 0.999 | 0.999 | 0.999 |
| Sargan *(p-value)* | 0.978 | 0.788 | 0.879 | 0.986 | 0.999 |
| Adjusted $R^2$ | 0.9695 | 0.9604 | 0.9407 | 0.9909 | 0.9938 |

**Notes:** Asymptotic t-statistics in parentheses (based on Huber-White heteroscedasticity robust standard errors). Regressions are estimated industry-by-industry, pooling observations across countries and over time. Estimation is by Instrumental Variables. All specifications include country-industry fixed effects and full set of industry-year dummies. Dependent variable is share of a sector in a country's GDP. Independent variables: Mskill1 is log number of males out of working age male population with low education relative to stock of physical capital; Mskill2 is log number of males with medium education relative to physical capital; Mskill3 is log number of males with high education relative to physical capital; Fskill1-Fskill3 are female educational endowments defined analogously; Arable is log arable land area relative to physical capital; P10 is log price of industry 10 output (Agriculture) relative to industry 30 output (Manufacturing), and so on for the other industries; industry 40 is Other Production; industry 50 is Other Services; industry 60 is Business Services; TFP10 is a log superlative index number measure of TFP in industry 10 relative to TFP in industry 30, and so on for the other industries. To abstract from short-run fluctuations all TFP measures are smoothed with a Hodrick-Prescott filter. Endogenous variables: P10, P40, P50, and P60. Exogenous variables Mskill1-Mskill3, Fskill1-Fskill3, TFP10-TFP60, Z10-Z60, Exrate, and Tariff. Z10 is a measure of log world prices at the border, calculated as trade-weighted sum of the price of industry 10 output in all other countries; Exrate is log nominal exchange rate; Tariff is the log average tariff rate. First-stage F-test is a test of the joint significance of the excluded exogenous variables in the first-stage regression for industry prices. Since each industry's price is normalised relative to manufacturing when linear homogeneity is imposed, there is no first-stage regression for manufacturing prices. Hausman is the Hausman (1978) specification test of the null hypothesis that within groups is consistent and efficient; Sargan is the Sargan (1958) test of the model's overidentifying restrictions.

## Table 7: Dynamic Within Groups Estimation: Partial Adjustment and the Role of Employment Protection

| **GDP share$_{ct}$** | **(1) Agriculture** | **(2) Manufact.** | **(3) Other Production** | **(4) Other Services** | **(5) Business Services** |
|---|---|---|---|---|---|
| Obs | 200 | 200 | 200 | 200 | 200 |
| Years | 1976-94 | 1976-94 | 1976-94 | 1976-94 | 1976-94 |
| GDP share$_{ct-1}$ ($\delta_0$) | 0.4297 | 0.5885 | 0.4452 | 0.6229 | 0.6247 |
| | *(4.810)* | *(10.224)* | *(3.455)* | *(7.070)* | *(11.065)* |
| EmProt*GDP share$_{ct-1}$ ($\delta_1$) | 0.0166 | 0.0181 | 0.0353 | 0.0139 | 0.0068 |
| | *(2.164)* | *(2.760)* | *(2.546)* | *(1.380)* | *(0.928)* |
| Mskill1$_{ct}$ ($\gamma_1$) | 0.0236 | -0.0362 | 0.0354 | 0.0058 | 0.0028 |
| | *(3.155)* | *(-2.565)* | *(2.217)* | *(0.465)* | *(0.288)* |
| Mskill2$_{ct}$ ($\gamma_2$) | 0.0091 | 0.0159 | -0.0338 | 0.0468 | -0.0581 |
| | *(0.760)* | *(0.801)* | *(-1.889)* | *(2.574)* | *(-4.097)* |
| Mskill3$_{ct}$ ($\gamma_3$) | 0.0019 | -0.0096 | 0.0212 | 0.0054 | 0.0015 |
| | *(0.323)* | *(-0.630)* | *(1.612)* | *(0.593)* | *(0.142)* |
| Fskill1$_{ct}$ ($\gamma_4$) | -0.0242 | 0.0280 | -0.0394 | 0.0043 | -0.0029 |
| | *(-2.847)* | *(1.790)* | *(-2.159)* | *(0.295)* | *(-0.253)* |
| Fskill2$_{ct}$ ($\gamma_5$) | -0.0047 | -0.0164 | 0.0227 | -0.0087 | 0.0394 |
| | *(-0.504)* | *(-0.942)* | *(1.392)* | *(-0.572)* | *(2.973)* |
| Fskill3$_{ct}$ ($\gamma_6$) | 0.0029 | -0.0036 | -0.0344 | -0.0028 | 0.0049 |
| | *(0.723)* | *(-0.302)* | *(-3.589)* | *(0.393)* | *(0.602)* |
| Arable$_{ct}$ ($\gamma_7$) | 0.0025 | 0.0576 | 0.0052 | -0.0587 | -0.0004 |
| | *(0.443)* | *(3.387)* | *(0.363)* | *(-4.699)* | *(-0.044)* |
| P10$_{ct}$ ($\alpha_1$) | 0.0196 | -0.0018 | -0.0294 | 0.0156 | 0.0031 |
| | *(7.943)* | *(-0.357)* | *(-2.686)* | *(2.625)* | *(0.764)* |
| P40$_{ct}$ ($\alpha_2$) | -0.0042 | -0.0258 | 0.0669 | -0.0138 | -0.0081 |
| | *(-2.119)* | *(-5.061)* | *(3.943)* | *(-2.497)* | *(-2.364)* |
| P50$_{ct}$ ($\alpha_3$) | -0.0002 | 0.0198 | -0.0160 | 0.0175 | -0.0319 |
| | *(-0.037)* | *(1.936)* | *(-1.078)* | *(1.574)* | *(-3.867)* |
| P60$_{ct}$ ($\alpha_4$) | -0.0025 | -0.0321 | -0.0060 | -0.0233 | 0.0559 |
| | *(-0.825)* | *(-3.438)* | *(-0.677)* | *(-2.579)* | *(7.561)* |
| TFP10$_{ct}$ ($\beta_1$) | 0.0106 | -0.0239 | 0.0016 | 0.0063 | 0.0020 |
| | *(3.524)* | *(-3.219)* | *(0.170)* | *(0.943)* | *(0.355)* |
| TFP40$_{ct}$ ($\beta_2$) | 0.0022 | -0.0130 | 0.0656 | -0.0102 | -0.0170 |
| | *(0.625)* | *(-1.759)* | *(3.733)* | *(-1.075)* | *(-2.618)* |
| TFP50$_{ct}$ ($\beta_3$) | 0.0050 | 0.0316 | -0.0396 | 0.0128 | -0.0076 |
| | *(1.294)* | *(2.802)* | *(-3.003)* | *(1.309)* | *(-0.913)* |
| TFP60$_{ct}$ ($\beta_4$) | -0.0004 | -0.0357 | 0.0204 | -0.0006 | 0.0235 |
| | *(-0.097)* | *(-2.919)* | *(1.647)* | *(-0.063)* | *(2.808)* |
| Year Dummies | yes | Yes | yes | yes | yes |
| Country-industry Fixed Effect | yes | Yes | yes | yes | yes |
| Adjusted $R^2$ | 0.9830 | 0.989 | 0.979 | 0.998 | 0.997 |

**Notes:** asymptotic t-statistics in parentheses (based on Huber-White heteroscedasticity robust standard errors). Regressions are estimated industry-by-industry, pooling observations across countries and over time. Estimation is by within groups (least squares dummy variables). All specifications include country-industry fixed effects and full set of industry-year dummies. Dependent variable is share of a sector in a country's GDP. Independent variables: EmProt is an OECD measure of the strength of employment protection institutions and policies which ranges from 1 to 20; Mskill1 is log number of males out of working age male population with low education relative to stock of physical capital; Mskill2 is log number of males with medium education relative to physical capital; Mskill3 is log number of males with high education relative to physical capital; Fskill1-Fskill3 are female educational endowments defined analogously; Arable is log arable land area relative to physical capital; P10 is log price of industry 10 output (Agriculture) relative to industry 30 output (Manufacturing), and so on for the other industries; industry 40 is Other Production; industry 50 is Other Services; industry 60 is Business Services; TFP10 is a log superlative index number measure of TFP in industry 10 relative to TFP in industry 30, and so on for the other industries. To abstract from short-run fluctuations all TFP measures are smoothed with a Hodrick-Prescott filter.

## 5.4. Contribution of Explanatory Variables to the Uneven Pace of Deindustrialization

In this section, we use our approach to decompose the uneven pace of deindustrialization across OECD countries into the contribution of individual explanatory variables. For simplicity, we focus on our baseline static within-groups specification, but the instrumental variables and dynamic within-groups estimation yield a similar pattern of results. The predicted values for the share of a sector in country GDP at a particular point in time are given by:

$$\hat{s}_{cjt} = \hat{\alpha}_{0j} + \hat{\beta}_j' X_{cjt} + \hat{\eta}_{cj} + \hat{d}_{jt} \tag{15}$$

where we have absorbed terms in relative prices, technology and factor endowments into the vector $X_{cjt}$ and their estimated coefficients into the vector $\hat{\beta}_j'$.

We indicate country means over time with a bar above a variable, time means across countries with a tilde above a variable, and means across both time and countries with a bar and a tilde above a variable. In this two-way fixed effects model, the constant, country fixed effects and time effects for each industry are identified from mean deviations:

$$\begin{aligned} \hat{\alpha}_{0j} &= \bar{\tilde{s}}_j - \hat{\beta}_j' \bar{\tilde{X}}_j \\ \hat{\eta}_{cj} &= \left(\bar{s}_{cj} - \bar{\tilde{s}}_j\right) - \hat{\beta}_j'\left(\bar{X}_{cj} - \bar{\tilde{X}}_j\right) \\ \hat{d}_{jt} &= \left(\tilde{s}_{jt} - \bar{\tilde{s}}_j\right) - \hat{\beta}_j'\left(\tilde{X}_{jt} - \bar{\tilde{X}}_j\right) \end{aligned} \tag{16}$$

where we have used the normalizations $\sum_c \eta_{cj} = \sum_t d_{jt} = 0$.

To examine the contribution of individual explanatory variables, we take differences in the predicted values for GDP shares between the beginning and end of the sample period in equation (15). The time-differencing eliminates the country-industry fixed effect. The impact on industrial structure of changes in relative prices, technology and factor endowments that are common across OECD countries is captured by the time dummies (see equation (16)). The uneven pace of deindustrialization across the OECD is explained by differential changes over time in relative prices, technology and factor endowments in individual countries. The contributions of the individual explanatory variables sum to the predicted change in GDP shares, and the within-sample predictive power of the model can be examined by comparing the predicted and actual changes in GDP shares.

Table 9 reports the results of undertaking this decomposition. Across countries and industries, the predicted change in GDP shares typically lies close to the actual change, providing evidence that the model is relatively successful in explaining the uneven pace of deindustrialization. For example, the average absolute prediction error in Manufacturing across all countries is 0.71% points, compared to an average initial GDP share of 25.34% points and an average actual change in GDP shares of 4.4% points. The model is typically least successful in Other Production, which is consistent with the existence of unobserved changes in known mineral resources that are important for this sector.

On average across OECD countries, there was a decline in the share of Agriculture and Manufacturing in GDP and a rise in the share of Business Services. This is reflected in the negative contribution of the year effects in Agriculture and Manufacturing, and the positive contribution of the year effects in Business Services, capturing the impact of common changes in relative prices, technology and factor endowments. The contribution of common changes in these variables is around four percentage points towards the decline of Manufacturing as a share of GDP and around one percentage point towards the rise of Business Services as a share of GDP.[24] However, there is much variation around these average trends, and the impact of differential changes in relative prices, technology and factor endowments on a sector's share of GDP in individual countries is typically larger in absolute value than the impact of common changes in these variables.

Taking industries one by one, there is a clear pattern to how the explanatory variables have contributed to the uneven pace of deindustrialization. In Manufacturing, we find that differences in TFP growth across OECD countries account for much of the variation in the growth of GDP shares. In Norway and the United Kingdom, which saw large decreases in the share of Manufacturing in GDP, there are large negative contributions from industry TFP growth. In Denmark, Germany, Japan, Netherlands and Sweden, which saw much smaller decreases in Manufacturing's share of GDP, there are substantial positive TFP contributions.

[24] The contribution of the year effects varies across countries due to variation in the time period over which data are available. Focusing on the group of countries where data exist during 1976-93 for each country yields a very similar pattern of results.

These contributions in the Manufacturing sector have general equilibrium consequences in other sectors. For example, the positive Manufacturing TFP effect in the Netherlands is associated with a negative effect in Other Services. Indeed, we find negative TFP contributions towards the growth of Other Services in a number of other countries as well, including Denmark, Finland, Sweden and the United Kingdom.

In Agriculture, the two countries where there are the largest falls in the sector's share of GDP are Italy and Japan. In both countries, the decline in Agriculture's share of GDP is largely accounted for by TFP growth and relative prices.

In Business Services, country-specific changes in relative prices over time explain much of the variation in the experience of this sector. Countries with large increases in the share of Business Services in GDP, such as Australia, the Netherlands, Sweden, the United Kingdom and the United States, typically experience substantial positive contributions from relative prices. In contrast, in Other Services, it is variation across countries in the evolution of educational attainment that explains much of the observed heterogeneity. In Australia, Canada, France, Italy, Japan, Netherlands, Sweden, West Germany, United Kingdom and United States, we observe large positive contributions from increases in educational attainment, consistent with many service sector activities being relatively skill-intensive.

**Table 9: Contribution of Explanatory Variables to Changes in Shares of GDP, Second-stage IV Parameter Estimates from Table 6**

| | (1) Agriculture | (2) Manufact. | (3) Other Production | (4) Business Services | (5) Other Services |
|---|---|---|---|---|---|
| **Australia (1983-93)** | | | | | |
| Actual Change in GDP Share | -1.68 | -3.20 | -3.97 | 5.57 | 3.76 |
| Predicted Change in GDP Share | -1.01 | -2.74 | -5.10 | 6.27 | 3.19 |
| Education (Male + Female) | 0.94 | -0.13 | -3.30 | 0.69 | 3.42 |
| Capital | 0.21 | -0.57 | -0.62 | 1.05 | 0.90 |
| Arable Land | -0.05 | 0.23 | 0.18 | 0.01 | -0.48 |
| TFP | -0.32 | -1.94 | -0.14 | -0.58 | 0.06 |
| Prices | 0.07 | 4.39 | -2.28 | 3.70 | -1.78 |
| Year Effects | -1.86 | -4.73 | 1.06 | 1.39 | 1.07 |
| **Belgium (1987-94)** | | | | | |
| Actual Change in GDP Share | -0.48 | -1.90 | 0.36 | -0.87 | 3.46 |
| Predicted Change in GDP Share | -0.57 | -1.23 | -0.59 | 0.89 | 1.31 |
| Education (Male + Female) | 0.86 | 0.87 | -1.46 | 0.80 | 0.65 |
| Capital | 0.14 | -0.38 | -0.42 | 0.71 | 0.60 |
| Arable Land | -0.24 | 1.09 | 0.85 | 0.04 | -2.21 |
| TFP | 0.95 | 0.12 | 1.49 | 0.71 | -0.01 |
| Prices | -1.31 | 0.06 | -0.99 | -2.37 | 1.39 |
| Year Effects | -0.98 | -2.99 | -0.06 | 1.00 | 0.88 |
| **Canada (1976-92)** | | | | | |
| Actual Change in GDP Share | -1.99 | -3.61 | -2.42 | 5.57 | 0.81 |
| Predicted Change in GDP Share | -2.17 | -4.20 | -2.15 | 5.51 | 1.67 |
| Education (Male + Female) | 0.83 | 1.32 | -4.04 | 0.33 | 2.96 |
| Capital | 0.44 | -1.17 | -1.28 | 2.18 | 1.86 |
| Arable Land | -0.04 | 0.20 | 0.16 | 0.01 | -0.41 |
| TFP | 0.92 | -0.78 | 0.43 | 0.66 | -0.07 |
| Prices | -1.24 | 1.22 | -1.21 | 1.34 | 0.36 |
| Year Effects | -3.07 | -4.99 | 3.79 | 0.99 | -3.02 |
| **Denmark (1984-92)** | | | | | |
| Actual Change in GDP Share | -2.38 | -1.09 | 0.82 | 1.28 | 1.27 |
| Predicted Change in GDP Share | -1.04 | -1.49 | -3.36 | 4.12 | 1.45 |
| Education (Male + Female) | 0.15 | 0.77 | -3.02 | 0.73 | 1.20 |
| Capital | 0.10 | -0.28 | -0.30 | 0.51 | 0.44 |
| Arable Land | 0.04 | -0.20 | -0.16 | -0.01 | 0.42 |
| TFP | 0.56 | 1.87 | 2.11 | -0.30 | -1.89 |
| Prices | -0.19 | 0.88 | -3.07 | 2.50 | 0.45 |
| Year Effects | -1.70 | -4.54 | 1.07 | 0.68 | 0.83 |
| **France (1983-92)** | | | | | |
| Actual Change in GDP Share | -1.52 | -2.83 | -1.00 | 4.56 | 1.75 |
| Predicted Change in GDP Share | -1.40 | -3.11 | -1.61 | 3.83 | 2.83 |
| Education (Male + Female) | 0.53 | 0.02 | -1.31 | -0.02 | 2.01 |
| Capital | 0.15 | -0.40 | -0.44 | 0.74 | 0.63 |
| Arable Land | -0.03 | 0.15 | 0.12 | 0.01 | -0.31 |
| TFP | 0.29 | 0.24 | 1.03 | -0.03 | -0.46 |
| Prices | -0.57 | 1.27 | -2.36 | 2.34 | 0.24 |
| Year Effects | -1.76 | -4.40 | 1.34 | 0.79 | 0.71 |

| | (1) Agriculture | (2) Manufact. | (3) Other Production | (4) Business Services | (5) Other Services |
|---|---|---|---|---|---|
| **Finland (1985-94)** | | | | | |
| Actual Change in GDP Share | -2.59 | -0.67 | -2.79 | 4.45 | -0.72 |
| Predicted Change in GDP Share | -2.08 | -2.32 | -2.98 | 4.46 | 0.65 |
| Education (Male + Female) | 0.93 | 0.21 | -1.10 | 0.36 | 1.40 |
| Capital | 0.16 | -0.42 | -0.46 | 0.79 | 0.67 |
| Arable Land | 0.01 | -0.03 | -0.02 | 0.00 | 0.06 |
| TFP | -1.26 | -0.67 | -0.42 | -1.84 | -1.29 |
| Prices | -0.30 | 2.61 | -1.16 | 3.53 | -1.14 |
| Year Effects | -1.62 | -4.01 | 0.19 | 1.61 | 0.95 |
| **Italy (1978-94)** | | | | | |
| Actual Change in GDP Share | -3.62 | -8.21 | -0.83 | 0.20 | 10.62 |
| Predicted Change in GDP Share | -3.23 | -7.86 | 0.10 | 1.35 | 9.01 |
| Education (Male + Female) | 2.06 | -0.04 | -5.22 | -0.38 | 6.87 |
| Capital | 0.33 | -0.88 | -0.96 | 1.64 | 1.40 |
| Arable Land | 0.20 | -0.91 | -0.71 | -0.04 | 1.85 |
| TFP | -1.63 | -0.90 | -3.74 | -0.21 | 2.15 |
| Prices | -1.42 | -0.62 | 8.44 | -1.06 | -1.83 |
| Year Effects | -2.76 | -4.50 | 2.29 | 1.40 | -1.45 |
| **Japan (1976-93)** | | | | | |
| Actual Change in GDP Share | -3.14 | -4.93 | 1.81 | 3.43 | 5.43 |
| Predicted Change in GDP Share | -3.45 | -5.47 | 2.50 | 3.88 | 4.57 |
| Education (Male + Female) | 1.89 | 0.38 | -3.56 | 0.95 | 3.70 |
| Capital | 0.71 | -1.90 | -2.07 | 3.53 | 3.02 |
| Arable Land | 0.15 | -0.67 | -0.52 | -0.03 | 1.36 |
| TFP | -2.01 | 2.55 | -1.54 | -1.01 | 0.62 |
| Prices | -1.01 | -0.51 | 6.68 | -1.15 | -1.46 |
| Year Effects | -3.17 | -5.33 | 3.51 | 1.58 | -2.67 |
| **Netherlands (1976-94)** | | | | | |
| Actual Change in GDP Share | -1.26 | -3.77 | -4.09 | 9.77 | 2.75 |
| Predicted Change in GDP Share | -0.98 | -3.55 | -3.53 | 10.48 | 1.79 |
| Education (Male + Female) | 2.12 | 1.67 | -4.79 | 2.47 | 3.03 |
| Capital | 0.28 | -0.74 | -0.80 | 1.37 | 1.17 |
| Arable Land | -0.22 | 1.01 | 0.79 | 0.04 | -2.06 |
| TFP | 1.29 | 8.50 | 0.25 | 1.32 | -2.91 |
| Prices | -1.22 | -9.04 | -2.24 | 3.36 | 5.22 |
| Year Effects | -3.23 | -4.95 | 3.27 | 1.92 | -2.66 |
| **Norway (1976-91)** | | | | | |
| Actual Change in GDP Share | -1.97 | -8.14 | 7.32 | 3.78 | -2.01 |
| Predicted Change in GDP Share | -1.80 | -8.29 | 7.94 | 4.41 | -2.96 |
| Education (Male + Female) | 0.55 | 0.81 | -0.59 | -0.40 | 0.47 |
| Capital | 0.39 | -1.04 | -1.14 | 1.94 | 1.65 |
| Arable Land | -0.18 | 0.83 | 0.65 | 0.03 | -1.69 |
| TFP | 0.19 | -5.99 | 5.66 | -1.19 | 0.96 |
| Prices | 0.28 | 1.37 | -0.50 | 3.10 | -1.06 |
| Year Effects | -3.03 | -4.28 | 3.86 | 0.94 | -3.31 |

| | (1) Agriculture | (2) Manufact. | (3) Other Production | (4) Business Services | (5) Other Services |
|---|---|---|---|---|---|
| **Sweden (1976-94)** | | | | | |
| Actual Change in GDP Share | -2.71 | -4.70 | -2.44 | 8.98 | 0.20 |
| Predicted Change in GDP Share | -2.80 | -3.69 | -2.20 | 8.88 | 0.22 |
| Education (Male + Female) | 2.19 | 0.83 | -3.30 | 1.40 | 2.94 |
| Capital | 0.32 | -0.85 | -0.92 | 1.58 | 1.34 |
| Arable Land | 0.12 | -0.56 | -0.43 | -0.02 | 1.13 |
| TFP | -1.31 | 2.05 | -0.41 | -1.94 | -2.43 |
| Prices | -0.88 | -0.23 | -0.40 | 5.94 | -0.11 |
| Year Effects | -3.23 | -4.95 | 3.27 | 1.92 | -2.66 |
| **West Germany (1985-93)** | | | | | |
| Actual Change in GDP Share | -0.71 | -5.46 | -0.78 | 0.38 | 6.34 |
| Predicted Change in GDP Share | -0.92 | -4.54 | -2.26 | 2.38 | 5.25 |
| Education (Male + Female) | 1.41 | -1.10 | -1.12 | -0.39 | 3.25 |
| Capital | 0.14 | -0.39 | -0.42 | 0.71 | 0.61 |
| Arable Land | 0.04 | -0.17 | -0.13 | -0.01 | 0.35 |
| TFP | 0.38 | 1.51 | 0.31 | 0.12 | -1.01 |
| Prices | -1.33 | 0.00 | -1.32 | 0.68 | 1.12 |
| Year Effects | -1.56 | -4.39 | 0.43 | 1.27 | 0.94 |
| **United Kingdom (1976-93)** | | | | | |
| Actual Change in GDP Share | -0.92 | -7.65 | -2.14 | 8.48 | 3.97 |
| Predicted Change in GDP Share | -1.30 | -9.16 | 0.09 | 8.88 | 2.22 |
| Education (Male + Female) | 1.98 | 1.52 | -4.43 | 1.91 | 3.56 |
| Capital | 0.29 | -0.78 | -0.85 | 1.45 | 1.24 |
| Arable Land | 0.20 | -0.92 | -0.72 | -0.04 | 1.87 |
| TFP | 0.25 | -4.70 | 3.87 | -1.73 | -1.43 |
| Prices | -0.86 | 1.04 | -1.29 | 5.70 | -0.36 |
| Year Effects | -3.17 | -5.33 | 3.51 | 1.58 | -2.67 |
| **United States (1976-93)** | | | | | |
| Actual Change in GDP Share | -1.39 | -5.48 | -2.07 | 8.64 | 1.22 |
| Predicted Change in GDP Share | -1.89 | -6.69 | -1.27 | 8.12 | 1.98 |
| Education (Male + Female) | 1.97 | 0.89 | -2.92 | 0.32 | 3.08 |
| Capital | 0.32 | -0.85 | -0.93 | 1.58 | 1.35 |
| Arable Land | 0.04 | -0.18 | -0.14 | -0.01 | 0.36 |
| TFP | 0.86 | -0.03 | -1.37 | 0.58 | -0.98 |
| Prices | -1.91 | -1.20 | 0.56 | 4.06 | 0.83 |
| Year Effects | -3.17 | -5.33 | 3.51 | 1.58 | -2.67 |

**Notes:** equation (6) is used to decompose the change in shares of GDP into the contributions of changes in the individual explanatory variables between the beginning and end of the sample period. Parameter estimates are taken from the second-stage IV results in Table 6. Education contribution calculated as follows. Multiply the change in the log of each education endowment by its estimated coefficient to yield the predicted effect of changes in that education endowment. Sum across education endowments to give the estimated contribution of changes in education to changes in shares of GDP. Contributions of other variables are calculated analogously. Since equation (6) is log linear, summing the contributions of individual variables yields the change in predicted shares of GDP. The table reports the average contributions over time for individual country-industries. Changes in shares of GDP and their components are reported as percentages. Thus, in Germany, Agriculture's share of GDP was predicted to fall by 0.92% points. The change in relative prices implied a fall in Agriculture's share of GDP of 1.33% points. The year effects capture the effect of changes in relative prices, technology and factor endowments that are common across countries. The time-period over which averages varies across countries, which explains the difference in the contribution from the year effects.

## 6. Conclusions

A central feature of economic growth in industrialized countries since the early 1970s has been the secular decline in manufacturing's share of GDP and the secular rise in the share of service sectors. Though this phenomenon is itself well known, the economic forces behind deindustrialization and the reasons why its pace varied so markedly across OECD countries are not well understood. We show how an econometric model founded in neoclassical production theory, and incorporating a role for technology, relative prices and factor supplies is able to explain the uneven pace of deindustrialization across OECD countries.

We find that the more rapid decline in Manufacturing's share of GDP in countries such as the United Kingdom and United States relative to countries such as Germany and Japan is largely explained by cross-country differences in industry productivity growth. The above average decline in agriculture's share of GDP in countries such as Italy and Japan is largely accounted for by industry productivity growth and relative price movements. Variation in the extent to which educational attainment increased across OECD countries is important in explaining why the share of Other Services in GDP rose by more in some countries than in others.

We also find that production structure responds very differently to the educational attainment levels of men and women. This is consistent with male and female students choosing different areas of specialization and acquiring different types of skills, as well as with the large labour market literature finding substantial differences in wages, occupation and industry between men and women of identical observable characteristics. While moving a man from low to medium education reduces the share of Agriculture and Other Production in GDP and increases the share of Manufacturing and Other Services, moving a woman from low to medium education reduces specialization in Manufacturing and increases specialization in Business Services.

Countries adjust gradually to changes in long-run patterns of specialization, and the speed of adjustment is found to vary systematically with levels of employment protection. This emphasizes the role of labour market institutions and policies in determining the speed with which resources can be reallocated from declining to expanding sectors. While there may be a variety of economic rationales for employment protection, an important cost is that it slows an economy's response to structural change.

## Appendix A: Imperfect Competition in the Neoclassical Model of Trade and Production

Following Helpman (1984), suppose that the representative consumer's utility function is weakly separable in the output of sectors $j=1,\ldots,n$, while, within each sector $j$, a variety of differentiated products are consumed $g=1,\ldots,G$,

$$U = U\left[u_1(\cdot), u_2(\cdot), \cdots, u_n(\cdot)\right] \tag{A1}$$

$$u_j(y_{j1}, \cdots, y_{jG}) = \left( \sum_{g=1}^{G} y_{jg}^{\beta_j} \right)^{1/\beta_j}, \qquad 0<\beta_j<1 \tag{A2}$$

where, for simplicity, we assume the sub-utility function $u_j(\cdot)$ takes the Dixit-Stiglitz form.

Production of differentiated varieties occurs under conditions of imperfect competition. Firms maximize profits subject to a downward-sloping demand curve, and profit maximization yields the standard result that equilibrium prices are a mark-up over marginal cost:

$$p_{jg} = p_j = \left( \frac{\sigma_j}{\sigma_j - 1} \right) . b_j(q) \tag{A3}$$

where $\sigma_j = 1 / (1-\beta_j)$ is the perceived elasticity of demand facing the producer of each variety in sector $j$ ; $b_j(\cdot)$ is the unit cost function – assumed to be the same for all producers in a given sector; $q$ is the vector of factor prices.

The revenue function is defined as the value of profit maximising outputs ($r(p,v) = p.y(p,v)$), where the value of output of good $j$ is the sum of the values of output for all varieties $g$ produced:

$$\sum_g p_{jg} . y_{jg} = p_j . \sum_g y_{jg} \ . \tag{A4}$$

Noting that the revenue function is defined in this way, the analysis in the main text continues to apply under imperfect competition.

# Appendix B: Data Sources

### B.1 Summary of educational attainment data sources

Three education groups: **(low)** no education or primary education; **(medium)** secondary or vocational education; **(high)** college degree or equivalent. The use of detailed information from country labour force surveys enables us to define these groups in as consistent a way as possible across countries, and our measures of educational attainment are a considerable advance over existing cross-country data sources. We control for any remaining cross-country differences in the classification of educational attainment in our econometric specification.

***Australia:*** data for population male & female separately from the "Labour Statistics Australia ABS Catalogue No.6101.0", 1982-93. Three groups: **(low)** Didn't attend highest level of Secondary School **(middle)** Attended highest level of Secondary School + Trade, Tech or Certificate **(high)** Degree.
***Belgium:*** data for population male & female separately from "Enquete sur les forces de travail" Statistiques Sociales, Ministere des Affaires Economiques, 1986-95. Three groups: **(low)** Enseignement primaire ou non **(middle)** Enseignement secondaire inferieur + Enseignement secondaire superieur + Enseignement superieur non universitaire de type court + Enseignement superieur non universitaire de type long **(high)** Enseignement universitaire
***Canada:*** data for population male & female separately from the "Annual Labour Force Averages" & "The Labour Force", 1975-95. Three groups (pre 1981): **(low)** 0-8 years **(middle)** Some high school & no post-secondary + Some post-secondary + Post-secondary certificate or diploma **(high)** University Degree. Three groups (1981-89): **(low)** 0-8 years **(middle)** 9-13 years + Some post-secondary + Post-secondary certificate or diploma **(high)** University Degree. Three groups (1990-96): **(low)** 0-8 years **(middle)** 9-13 years + Graduated from high school + Some post-secondary + Post-secondary certificate or diploma **(high)** University Degree.
***Denmark:*** data for population male & female separately from the Danish Annual Statistics "Statistik Arbog", 1983-95. Three groups: **(low)** second level, first stage **(middle)** second level, second stage (general and vocational) and education at the third level, first stage (university and non-university type) **(high)** third level, second stage.
***France:*** data for labour force male & female separately from the "Enquete sur l'emploi: resultats detaille", les collections de l'insee, institut national de la statistique et des etudes economiques, 1982-95. Three groups (pre 1994): **(low)** Aucun diplome ou certificat d'etudes (cep) seul **(middle)** Brevet d'etudes du premier cycle (bepc) seul + Cap, bep, ou autre diplome de ce niveau + Baccalaureat ou brevet professional, ou autre diplome de ce niveau **(high)** Diplome du 1er cycle universitaire, bts, dut, diplome paramedical ou social + Diplome du 2e or 3e cycle universitiaire, diplome d'une grande ecole ou ecole d'ingenier. Three groups (1994 onwards): **(low)** Aucun diplome ou CEP **(middle)** BEPC seul + Cap, bep, ou autre diplome de ce niveau + Baccalaureat, brevet professional ou autre diplome de ce niveau **(high)** Baccalaureat + 2 ans + Diplome superieur.
***Finland:*** data for population male & female separately from the "Tyovoiman koulutus ja ammatit" Statistics Finland, 1984-95. Three groups: **(low)** Basic education only **(middle)** Upper secondary education - lower level + Upper secondary education – upper level **(high)** Higher education - lower level + Higher education – upper level.
***Germany:*** data for population male & female separately from German Socio-Economic Panel (GSOEP), 1984-95. Three groups: **(low)** 9 years of schooling + no vocational **(middle)** 10 years of schooling and no vocational + 9 years of schooling and some vocational + 10 years of schooling and some vocational + 13 years of schooling + College **(high)** University.
***Italy:*** data for population male & female separately from "Indagine sulle forze di lavoro" in the table "Forze di lavoro secondo di sesso, la classe di eta, il titolo di studio e la condizione", 1977-95. Three groups (pre 1993): **(low)** Senza titolo e licenza elementare **(middle)** Licenza scuola media inferiore + Licenza scuola media superiore **(high)** Laurea. Three groups (1993+): **(low)** Dottorato di ricerca o Specializzazione + Laurea **(middle)** Diploma Univ. o Laureabreve + Diploma accesso Universita + Qualifica Lic. Non accesso Universita + Licenza media **(high)** Licenza elementare, nessun titolo.
***Japan:*** data for labour force male & female separately from the Employment Status Survey published by the Statistics Bureau, Management and Coordination Agency, Government of Japan, 1975-95. Three groups: **(low pre 1980)** never attended, elementary school and Junior high school **(low post 1980)** elementary school and Junior high school **(middle)** Senior high school and Junior college, technical college **(high)** College or university, including graduate school.
***Netherlands:*** .data for population male & female separately from the Population Survey (Volkstelling), the Annual Labour Force Survey (Arbeidskrachtentelling (AKT)) and the Monthly Labour Force Survey (Enquete Beroepsbevolking (EBB)), 1975-95. Three groups: **(low)** no qualifications **(middle)** lower + intermediate **(high)** higher qualifications.
***Norway:*** data for population male & female separately from Statistical Yearbook of Norway, Statistics Norway, 1975-95. Three groups: **(low)** Unknown or no completed education **(middle)** Education at the second level, first stage + Education at the second level, second stage **(high)** Education at the third stage.

***Sweden:***. data for population male & female separately from Swedish Labour Force Survey, 1975-95. Three groups: **(low)** Elementary school (< 9 years) + 9-year compulsory school **(middle)** Upper secondary school, 2 years or shorter + Upper secondary school, 3 years **(high)** Tertiary (post-secondary) education, 3 years or longer + postgraduate education.
***UK:*** data for population male & female separately from General Household Survey, 1975-95. Three groups (1977-90): **(low)** no qualifications **(middle)** voc-high + teaching + nursing + A-level + voc-middle + O-level 5+ + voc-low + O-level & clerical + O-level 1-4 + clerical + voc-other + other **(high)** University. Three groups (1991-95): **(low)** no qualifications **(middle)** Teaching + other high + nursing + gce a level + gce a level + gcse & olevel + gcse & olevel + gcse & olevel + comm q, n + cse grd + apprenticeship + scst g6- + foreign + other qual **(high)** higher degree + first degree.
***USA:*** data for population male & female separately are from the Current Population Survey (CPS), 1975-95. Three groups: **(low)** non high school graduates **(middle)** high school graduates + college and associated degrees **(high)** bachelors and higher.

## B2. Production Data and Other Independent Variables

**OECD International Sectoral Database (ISDB):** data on current price value-added, real value-added (1990 US dollars), real physical capital stock (1990 US dollars), employment, and hours worked for the one-digit industries listed in Table 1B in the main text for the years 1976-94. Data on current price GDP and aggregate real physical stock (1990 US dollars) for 1976-94.
**United Nations FAO:** data on arable land area (thousands of hectares) for 1970-94.
**OECD Bilateral Trade Database:** data on bilateral imports between the 14 OECD countries for 1970-94 used to construct prices at the border.
**OECD Structural Analysis Industrial Database (STAN):** data on nominal exchange rates for converting prices at the border to national currencies.
**IMF International Financial Statistics, IMF Government Finance Statistics, and Annual Reports of the European Commission:** data on the ratio of tariff revenues to the value of imports. See Djankov *et al.* (1999) for further information concerning these data.
**OECD Jobs Study: Evidence and Explanations:** ranking of countries in terms of their strength of employment protection, 1989-94. The complete OECD ranking, including countries not in our sample, is: USA 1; New Zealand 2; Canada 3; Australia 4; Denmark 5; Switzerland 6; United Kingdom 7; Japan 8; The Netherlands 9; Finland 10; Norway 11; Ireland 12; Sweden 13; France 14; Germany 15; Austria 16; Belgium 17; Portugal 18; Spain 19; Italy 20.

**Table B1: Breakdown of the Disaggregated Sectors Included in each One-Digit Industry (International Standard Industrial Classification (ISIC))**

| Code | ISIC | Industry |
|---|---|---|
| 10 | 10 | Agriculture, Hunting, Forestry, and Fishing |
| | 11 | Agriculture and Hunting |
| | 11.1 | Agriculture and Livestock Production |
| | 11.2 | Agricultural Services |
| | 11.3 | Hunting, Trapping, and Game Propagation |
| | 12 | Forestry and Logging |
| | 12.1 | Forestry |
| | 12.2 | Logging |
| | 13 | Fishing |
| | 1301 | Ocean and Coastal Fishing |
| | 1302 | Fishing Not Elsewhere Classified |
| 30 | 30 | Manufacturing |
| | 31 | Food, Beverages, and Tobacco |
| | 32 | Textile, Wearing Apparel, and Leather Industries |
| | 33 | Wood and Wood Products, Including Furniture |
| | 34 | Paper and Paper Products; Printing and Publishing |
| | 35 | Chemicals and Chemical Products; Petroleum, Coal, Rubber, and Plastic |
| | 36 | Non-metallic Mineral Products, except Petroleum and Coal |
| | 37 | Basic Metal Industries |
| | 38 | Fabricated Metal Products, Machinery and Equipment |
| | 39 | Other Manufacturing Industries |
| 40 | | Other Production |
| | 20 | Mining and Quarrying |
| | 21 | Coal Mining |
| | 22 | Crude Petroleum and Natural Gas Production |
| | 23 | Metal Ore Mining |
| | 29 | Other Mining |
| | 40 | Electricity, Gas, and Water |
| | 41 | Electricity, Gas, and Steam |
| | 42 | Water Works and Suppy |
| | 50 | Construction |
| | | Construction of Dwellings |
| | | Construction of Non-residential Buildings |
| | | Civil Engineering Works |
| | | Demolition of Buildings |
| 602 | 80 | Business Services |
| | 81 | Financial Institutions |
| | 8101 | Monetary Institutions |
| | 8102 | Other Financial Institutions |
| | 8103 | Financial Services |
| | 82 | Insurance |
| | 83 | Real Estate and Business Services |
| | 831 | Real Estate |
| | 832 | Business Services Except Machinery and Equipment Rentals and Leasing |
| | 833 | Machinery and Equipment Rental and Leasing |

**Table B1 (cont): Breakdown of the Disaggregated Sectors Included in each One-Digit Industry (International Standard Industrial Classification (ISIC))**

| Code | ISIC | Industry |
|---|---|---|
| 601 | | Other Services |
| | 60 | Wholesale and Retail Trade, Restaurants and Hotels |
| | 61 | Wholesale Trade |
| | 62 | Retail Trade |
| | 63 | Restaurants and Hotels |
| | 631 | Restaurants, Cafes, and Other Eating and Drinking Places |
| | 632 | Hotels, Rooming Houses, Camps, and Other Lodging Places |
| | 70 | Transport, Storage, and Communication |
| | 71 | Transport and Storage |
| | 711 | Land Transport |
| | 712 | Water Transport |
| | 713 | Air Transport |
| | 719 | Services Allied to Transport |
| | 72 | Communication |
| | 90 | Community, Social, and Personal Services |
| | 91 | Public Administration and Defence |
| | 92 | Sanitary and Similar Services |
| | 93 | Social and Related Community Services |
| | 931 | Education Services |
| | 932 | Research and Scientific Institutes |
| | 933 | Medical, Dental, Other Health, and Veterinary Services |
| | 934 | Welfare Institutions |
| | 935 | Business, Professional, and Labour Associations |
| | 939 | Other Social and Related Community Services |
| | 94 | Recreational and Cultural Services |
| | 941 | Motion Picture and Other Entertainment Services |
| | 942 | Libraries, Museums, Botanical Gardens, and Other Cultural Services nes |
| | 949 | Amusement and Recreational Services nes |
| | 95 | Personal and Household Services |
| | 951 | Repair Services nes |
| | 96 | International and Other Extra-territorial Bodies |
| 100 | | Producers of Government Services and Other Producers |
| | | Producers of Government Services |
| | | Other Producers |
| | | |
| 1000 | | Total Including All Taxes |

**Table B2: Female & Male Employment as a Percentage of Total Employment, United Kingdom, 1975, 1985 & 1995**

| Industry | | Year | Percentage |
|---|---|---|---|
| **Agriculture** | | | |
| | Male | 1975 | 84.4 |
| | | 1985 | 83.0 |
| | | 1995 | 79.4 |
| | Female | 1975 | 15.6 |
| | | 1985 | 17.0 |
| | | 1995 | 20.6 |
| **Manufacturing** | | | |
| | Male | 1975 | 69.6 |
| | | 1985 | 71.5 |
| | | 1995 | 71.0 |
| | Female | 1975 | 30.4 |
| | | 1985 | 28.5 |
| | | 1995 | 29.0 |
| **Other Production** | | | |
| | Male | 1975 | 86.0 |
| | | 1985 | 85.5 |
| | | 1995 | 80.8 |
| | Female | 1975 | 14.0 |
| | | 1985 | 14.5 |
| | | 1995 | 19.2 |
| **Business Services** | | | |
| | Male | 1975 | 52.5 |
| | | 1985 | 46.6 |
| | | 1995 | 42.2 |
| | Female | 1975 | 47.5 |
| | | 1985 | 53.4 |
| | | 1995 | 57.8 |
| **Other Services** | | | |
| | Male | 1975 | 53.5 |
| | | 1985 | 50.4 |
| | | 1995 | 50.0 |
| | Female | 1975 | 46.5 |
| | | 1985 | 49.6 |
| | | 1995 | 50.0 |

**Notes:** for each year and each industry, the male employment percentage is number of male employees divided by total number of employees (male plus female) expressed as a percentage. The female employment percentage is defined analogously. Source: United Kingdom New Earnings Survey.

**Table B3: Percentages of Female & Male Employment by Skill Level, United Kingdom, 1975, 1985 & 1995**

| Industry | | Year | Low | Medium | High |
|---|---|---|---|---|---|
| **Agriculture** | | | | | |
| | Male | 1975 | 3.03 *(2.56)* | 92.36 *(77.94)* | 4.61 *(3.89)* |
| | | 1985 | 3.12 *(2.59)* | 92.57 *(76.80)* | 4.30 *(3.57)* |
| | | 1995 | 1.89 *(1.50)* | 94.25 *(74.80)* | 3.86 *(3.07)* |
| | Female | 1975 | 5.12 *(0.80)* | 89.42 *(13.96)* | 5.46 *(0.85)* |
| | | 1985 | 3.38 *(0.58)* | 91.89 *(15.66)* | 4.73 *(0.81)* |
| | | 1995 | 3.63 *(0.75)* | 92.74 *(19.14)* | 3.63 *(0.75)* |
| **Manufacturing** | | | | | |
| | Male | 1975 | 6.07 *(4.23)* | 82.71 *(57.60)* | 11.22 *(7.82)* |
| | | 1985 | 5.33 *(3.81)* | 80.44 *(57.50)* | 14.23 *(10.17)* |
| | | 1995 | 3.81 *(2.70)* | 77.51 *(55.05)* | 18.68 *(13.27)* |
| | Female | 1975 | 6.74 *(2.05)* | 90.18 *(27.37)* | 3.08 *(0.93)* |
| | | 1985 | 5.31 *(1.51)* | 90.59 *(25.84)* | 4.11 *(1.17)* |
| | | 1995 | 3.45 *(1.00)* | 89.90 *(26.05)* | 6.65 *(1.93)* |
| **Other Production** | | | | | |
| | Male | 1975 | 12.63 *(10.86)* | 75.52 *(64.95)* | 11.85 *(10.20)* |
| | | 1985 | 12.43 *(10.63)* | 73.82 *(63.13)* | 13.74 *(11.75)* |
| | | 1995 | 8.56 *(6.91)* | 68.12 *(55.04)* | 23.32 *(18.84)* |
| | Female | 1975 | 9.25 *(1.29)* | 86.29 *(12.07)* | 4.46 *(0.62)* |
| | | 1985 | 8.38 *(1.21)* | 84.74 *(12.27)* | 6.88 *(1.00)* |
| | | 1995 | 4.15 *(0.80)* | 84.86 *(16.30)* | 10.99 *(2.11)* |
| **Business Services** | | | | | |
| | Male | 1975 | 11.31 *(5.94)* | 70.39 *(36.95)* | 18.31 *(9.61)* |
| | | 1985 | 10.70 *(4.99)* | 69.88 *(32.58)* | 19.43 *(9.06)* |
| | | 1995 | 11.05 *(4.67)* | 67.74 *(28.60)* | 21.20 *(8.95)* |
| | Female | 1975 | 16.05 *(7.62)* | 70.50 *(33.49)* | 13.45 *(6.39)* |
| | | 1985 | 15.38 *(8.21)* | 70.13 *(37.43)* | 14.49 *(7.73)* |
| | | 1995 | 12.25 *(7.08)* | 72.80 *(42.06)* | 14.95 *(8.64)* |
| **Other Services** | | | | | |
| | Male | 1975 | 5.21 *(2.79)* | 73.03 *(39.08)* | 21.75 *(11.64)* |
| | | 1985 | 3.49 *(1.76)* | 71.28 *(35.91)* | 25.23 *(12.71)* |
| | | 1995 | 2.87 *(1.44)* | 67.95 *(34.01)* | 29.18 *(14.60)* |
| | Female | 1975 | 4.24 *(1.97)* | 90.67 *(42.15)* | 5.09 *(2.37)* |
| | | 1985 | 2.99 *(1.48)* | 90.90 *(45.10)* | 6.11 *(3.03)* |
| | | 1995 | 2.53 *(1.26)* | 86.18 *(43.05)* | 11.29 *(5.64)* |

**Notes:** the value 3.03 in the top left-hand cell is the number of men with low skill in Agriculture in 1975 expressed as a percentage of all male employees. The values for women and for the other cells are defined analogously. The figures in parenthesis are expressed as a percentage of all employees. The value 2.56 in the top left-hand cell is thus the number of men with low skill in Agriculture in 1975 expressed as a percentage of all employees (male plus female). The values for women and for the other cells are defined analogously. Source: United Kingdom New Earnings Survey.

# Appendix C: Panel Data Unit Root Tests

The Levin and Lin (1992) panel data unit root test is based on the regression:

$$y_{ct} = \rho y_{ct-1} + \eta_c + \varepsilon_{ct} \tag{C1}$$

Observations are pooled across countries and over time, and the autoregressive parameter, $\rho$, is assumed to be the same across countries. The null hypothesis is, $H_0 : \rho = 1$, and the alternative hypothesis is, $H_1 : \rho < 1$.

The Maddala and Wu (1999) panel data unit root test is based on the regression:

$$\Delta y_{ct} = \rho_c y_{ct-1} + \alpha_1 \Delta y_{ct-1} + \alpha_2 \Delta y_{ct-2} + \eta_c + \varepsilon_{ct} \tag{C2}$$

The equation is estimated separately for each country so that the autoregressive parameter, $\rho$, is allowed to vary across countries. The null hypothesis is, $H_0 : \rho_c = 0$ for $c = 1,2,\ldots,C$, and the alternative hypothesis is, $H_1 : \rho_c < 0$. Denote the MacKinnon approximate $p$-value for the parameter $\rho_c$ in the regression for an individual country by $\pi_c$ ($c=1,2\ldots,C$). Following Fisher (1932), Maddala and Wu *op cit.* note that $\lambda = -2 \sum_c \ln(\pi_c)$ is distributed $\chi^2(2C)$.

### Table C1: Unit Root Tests (Levin and Lin (1992) and Maddala and Wu (1999))

| Levin-Lin | | Maddala-Wu | |
|---|---|---|---|
| **Variable** | **Test Statistic** | **Variable** | **Test Statistic** |
| $Mskill1_{ct}$ | -2.071 | $Mskill1_{ct}$ | 73.011 |
| $Mskill2_{ct}$ | -5.485 | $Mskill2_{ct}$ | 15.299 |
| $Mskill3_{ct}$ | -5.948 | $Mskill3_{ct}$ | 90.047 |
| $Fskill1_{ct}$ | -1.776 | $Fskill1_{ct}$ | 17.621 |
| $Fskill2_{ct}$ | -8.166 | $Fskill2_{ct}$ | 20.411 |
| $Fskill3_{ct}$ | -7.460 | $Fskill3_{ct}$ | 101.824 |
| $Arable_{ct}$ | -2.592 | $Arable_{ct}$ | 50.352 |
| $P10_{ct}$ | -9.011 | $P10_{ct}$ | 13.301 |
| $P40_{ct}$ | -6.339 | $P40_{ct}$ | 32.670 |
| $P50_{ct}$ | -5.094 | $P50_{ct}$ | 39.438 |
| $P60_{ct}$ | -5.214 | $P60_{ct}$ | 8.813 |
| $TFP10_{ct}$ | -5.364 | $TFP10_{ct}$ | 115.300 |
| $TFP40_{ct}$ | -4.117 | $TFP40_{ct}$ | 17.145 |
| $TFP50_{ct}$ | -6.626 | $TFP50_{ct}$ | 23.696 |
| $TFP60_{ct}$ | -1.854 | $TFP60_{ct}$ | 94.296 |
| | | | |
| $Gdpsh10_{ct}$ | -5.974 | $Gdpsh10_{ct}$ | 19.432 |
| $Gdpsh30_{ct}$ | -2.371 | $Gdpsh30_{ct}$ | 22.345 |
| $Gdpsh40_{ct}$ | -1.734 | $Gdpsh40_{ct}$ | 53.389 |
| $Gdpsh50_{ct}$ | -1.762 | $Gdpsh50_{ct}$ | 44.240 |
| $Gdpsh60_{ct}$ | -0.607 | $Gdpsh60_{ct}$ | 36.748 |

**Notes:** Mskill1 is log number of males out of working age male population with low education relative to stock of physical capital; Mskill2 is log number of males with medium education relative to physical capital; Mskill3 is log number of males with high education relative to physical capital; Fskill1-Fskill3 are female educational endowments defined analogously; Arable is log arable land area relative to physical capital; P10 is log price of industry 10 output (Agriculture) relative to industry 30 output (Manufacturing), and so on for the other industries; industry 40 is Other Production; industry 50 is Other Services; industry 60 is Business Services; TFP10 is a log superlative index number measure of TFP in industry 10 relative to TFP in industry 30, and so on for the other industries. Gdpsh10 is share of industry 10 in country GDP, and so on for the other industries. $\Delta$ denotes the difference operator. Critical values for the Levin and Lin test are from Table 5, Levin and Lin (1992): 1% critical value = -6.72; 5% critical value = -6.28; 10% critical value = -6.04. The Chi-squared (28) critical values for the Maddala and Wu test are, 1% : 48.2782; 5% : 41.3372; 10% : 37.9159.

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