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Assessing the Impact of Trade Policy on Labor Markets and Production

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Assessing the Impact of Trade Policy on Labor Markets and Production

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Assessing the Impact of Trade Policy on Labour Markets and Production

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Abstract: This paper discusses the measurement of production and employment effects of trade policy, and more broadly the effects of economic integration and globalization. First, it provides a broad-brush overview of the ex-post literature linking trade to performance, such as measures of worker displacement, adjustment costs, and econometric evidence on trade and wages. It then defines structural impact indexes, illustrating their use with a stylized CGE model-based assessment of the impact of EU enlargement on the transition economies. Finally, the last section discusses the gap between our ex-post experience with adjustment costs, and what ex-ante methods actually tell us.

Key words: adjustment costs, labour displacement, output effects of trade liberalization

JEL Codes: F16, F13, F17

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How does trade policy affect patterns of production and employment, and how does this manifest itself in terms of adjustment costs? This paper is concerned with these issues, exploring how we approximate the production and employment effects of trade liberalization, and more broadly the effects of economic integration. The issue is clearly important, as there is a public perception that “globalization,” however defined, is driving negative labour market trends. This in turn has coloured the willingness of the OECD governments, under pressure from NGOs and their own electorates, to push for further liberalization initiatives. It also colours our sense of developing country gains from liberalization.

The paper is organized as follows. The next section discusses econometric approaches to measurement of adjustment costs. This is followed by a discussion of the literature on linkages between economic integration, division of labour processes, and labour market adjustment. The next section then defines structural impact indexes for impact assessments. While these indexes can be used for ex-post or ex-ante assessments, their use is illustrated in a numeric (CGE-based) example. The last section concludes.

1. ADJUSTMENT COST MEASUREMENT

At its most basic level, the measurement of the effects of trade liberalization on welfare generally involves comparison of welfare levels before and after liberalization, and after all factors of production have found their new long-run occupations. However, such calculations need to be adjusted for possible losses during the transition to the new long-run situation, in particular if this transition takes a long time. That is, proper welfare calculus needs to allow for *social adjustment costs*.¹

A standard measurement of social adjustment costs is the value of output that is foregone in the transition to new long-run production patterns because of the time taken to reallocate factors from their pre- to their post-liberalization occupations. There are also other

¹ A more extensive discussion of adjustment costs is provided by Matusz (1997).

costs that are harder to quantify, such as the mental suffering of unemployed workers, which normally fall outside the realm of economic analysis. The magnitude of adjustment costs is a direct reflection of the speed at which the economy manages to redirect resources in response to liberalization. For this reason, they depend on a large number of factors.² However, the flexibility of labour markets and credit markets is especially important. If firms in sectors with potential for expansion do not have strong incentives to hire new employees, for instance because of administrative regulations or externally imposed labour market contract requirements, the adjustment will be more costly than otherwise. Likewise, firms will need to invest in order to exploit new opportunities, and this requires access to credit. The possibility of smooth adjustment also depends on the functioning of other markets. For example, the possibility for labour to find alternative employment may depend on the housing market. At the same time, there may be a trade-off between displacement and efficiency gains.

Adjustment costs are also influenced by the degree of ease with which firms in *contracting* sectors are able to release factors. For instance, if production in these firms is maintained through government support, the adjustment process might be prolonged. This is not to say, however, that it would be economically desirable that factors are laid off immediately after liberalization. From a purely economic point of view, minimization of adjustment costs requires a careful balance between the speed at which factors are released and the speed at which they can be re-employed. It is sometimes argued that the existence of adjustment costs makes it desirable for the trade liberalization process itself to be gradual.

² The question of the appropriate design of government measures to ease adjustment has been the focus of a recent analytical economic literature, see e.g. *Journal of International Economics* 36, 1994, which contains several contributions. There is also an empirical literature which considers the efficiency of adjustment programmes. A common finding is that the resources spent on these programmes do not reach the intended targets, but are appropriated by others, see eg. Richardson (1982).

The question of the appropriate speed of trade liberalization is complex, however, and typically also involves the question of political credibility.

In theory, trade liberalization may entail a net welfare loss if the gains are sufficiently small relative to the adjustment costs. However, such adjustment costs would have to be very large relative to the standard gains from trade liberalization in order to dominate the latter. Adjustment costs are temporary and must be set against an indefinite stream of future higher incomes. It would therefore take very large costs, or a very short-run perspective (i.e. a high discount rate) in order for the costs to outweigh the gains. This is further reinforced by the fact that the (static) gains from trade liberalization tend to grow over time as a result of general economic growth.

In addition to aggregate effects, one can also consider these costs from the point of view of individuals (*private* adjustment costs). One reason why these may be important is that private adjustment costs are typically unevenly distributed, as some factor markets work more smoothly than others to redirect resources that are freed up through liberalization. There may also be strong regional differences that imply that different factor owners experience different adjustment costs. The distributional consequences of adjustment can have two important ramifications. First, they may generally be perceived of as being undesirable, and may thus call for some form of government intervention on equity grounds, in contrast to social adjustment costs which might require government measures on efficiency grounds. But, as always, the least-cost way of providing this assistance would very rarely be in the form of protection, but more plausibly as retraining, housing, income support, and so on.³

Another reason why adjustment costs may be important involves political economy. Private adjustment costs are significant determinants, together with the long-run effects of

³ The World Bank (1997) discusses policy measures to ease adjustment costs from a developing country perspective.

trade liberalization, of the identity of winners and losers from trade liberalization. They influence the line-up of interests that might oppose trade liberalization, despite any aggregate gains it may bring. There is a fair amount of empirical evidence that trade liberalization may entail significant losses for some groups. For instance, several studies report that replaced workers may earn substantially less in their new occupations, even several years after replacement. (Jacobson et al (1993a,b) provide examples of the former case for the United States, while a more positive picture is painted in Mills' and Sahn's (1995) study of Guinea.) Whether this is a temporary phenomenon, and thus an adjustment cost, or a permanent phenomenon, is often difficult to determine.

The empirical literature on the magnitude of adjustment costs from trade liberalization was rather thin until recently. This is probably a reflection of the perception among researchers during the 1960s and 1970s that adjustment costs were typically quite small in proportion to the aggregate gross gains, an impression that is supported by the limited number of studies that were undertaken. One approach has been to study outlays in Trade Adjustment Assistance (TAA) schemes in the United States. According to Richardson (1982), total outlays in trade adjustment assistance under the US Trade Expansion Act of 1962 were approximately US\$75 million for the period 1962-75. The corresponding figure for assistance under the US Trade Act of 1974 for the period 1975-79 was approximately US\$870 million, with a sharp increase in 1980-81 due to the auto-centred recession.

Another method which has also been employed in relation to temporary unemployment from trade liberalization is to obtain a rough estimate of the temporary income loss by multiplying an estimate of the average amount of time workers are unemployed with an estimate of their average wage. This method was employed in a series of papers in the mid-1970s. For instance, Bale (1976) estimated from a sample of workers assisted under the US Trade Expansion Act of 1962 that the average income loss was

US\$3,370 during 1969-70 for a worker who was displaced because of import competition, before taking into account such factors as trade adjustment assistance and unemployment insurance.

A different approach is taken by Takacs and Winters (1991) in their study of the likely effects of the removal of quantitative restrictions in the British footwear industry. A starting point of their analysis is the observation that there is a fairly high natural rate of turnover in the industry, even absent trade liberalization (almost 17 percent per year). Takacs and Winters estimate the adjustment costs and the long-run benefits from removal of these quantitative barriers, taking into account this turnover. The magnitude of these estimates varies according to the underlying assumptions that are used. However, the authors report that even under their most pessimistic scenario, the adjustment costs are almost negligible in comparison to the potential gains from trade liberalization – that is, slightly less than £10 million in losses compared to £570 million in gains.

A more indirect way of assessing the magnitude of adjustment costs has been to estimate the share of the restructuring of trade that takes place *within* industries.⁴ The basic idea is that it is easier for factors of production to move from one occupation to another in the same industry, rather than to switch industries. From this point of view one should expect increased import competition between developed countries to be associated with smaller adjustment costs per lost job than when the loss stems from expansion of trade associated with increased exploitation of comparative advantage.

There are also other methods of assessing the magnitudes of adjustment costs.⁵ It should be noted, however, that regardless of the method employed, these calculations should be viewed with caution. For instance, since the costs and benefits of liberalization are

⁴ See, for example Greenaway et al. (1999).

⁵ Examples of other empirical studies, employing a variety of methods, are Baldwin, Mutti and Richardson (1980), de Melo and Roland-Holst (1994), Magee (1972), de Melo and Tarr (1990), and Mutti (1978).

typically distributed unevenly through time, they are sensitive to the assumed rate of discounting of future gains and losses - an assumption which by its very nature must be quite arbitrary. However, despite differences in methodological approach and in underlying assumptions, ex-post empirical studies typically convey the message that social adjustment costs are small, in aggregate, in comparison to the standard gains from trade liberalization. At the same time, they can be very significant for the individuals affected.

2. WAGES

While trade liberalization may enlarge the economic pie, its allocation can be affected by trade liberalization even as it is enlarged. Understandably, this is a highly sensitive issue. For this reason, though technology appears to emerge from the data as the current driving force behind recent labour market changes, the linkage between trade liberalization and labour market conditions will continue to be an important issue. Additionally, while the Heckscher-Ohlin argument for trade-wage linkages does not loom large in the evidence, more recent work on alternative frameworks does point to potentially strong linkages through alternative channels. (See Francois and Nelson 2004, Goldberg and Pavcnik 2003.)

For the great majority of the research on the link between trade and wages, the logic of the argument is straightforwardly represented by the *Stolper-Samuelson theorem*, and the source of the problem is seen, more-or-less explicitly, to be trade with developing countries. (The Stolper-Samuelson theorem is derived from the same theoretical explanations of comparative advantage discussed earlier with respect to the allocation gains from trade. It points to an immediate link between trade prices and relative labour income.) Despite the beauty of the theory, a compelling argument against the plausibility of Stolper-Samuelson-based arguments is that trade with developing countries constitutes too small a share of OECD economic activity to generate effects of the magnitude observed in the 1980s.

Another weakness in the story is evidence that the earnings/employment gap has opened in the same direction across developing countries as well (see Wood 1997), suggesting that it may be technology rather than trade that is driving events.

Given the ease with which the HOS model yields an estimating framework, it is not surprising that the empirical literature on trade and wages has derived primarily from competitive models of the HOS family. By contrast, imperfectly competitive models come in a variety of forms, most of which do not yield as readily to econometric representation as do the competitive models. For this reason, work in imperfectly competitive frameworks has been largely CGE-based. Even so, we do have some econometric evidence of economic geography mechanisms, and related effects, outside the HOS framework. Building on the fundamental work of Ethier (1982) and Markusen (1990), Markusen and Venables (1997, 1999) develop a two-sector, two-factor model characterized by one conventional (i.e. constant returns to scale) sector and one sector characterized by monopolistic competition and division of labour induced external scale economies. Markusen and Venables are interested in North-South issues, so their two-country model involves endowment differences as well as the division of labour structure. Within this framework, the authors show that effects of a reduction in barriers to multinationalization have ambiguous effects on the wage premium. Using a similar production structure, Lovely and Nelson (2000) examine trade between similar countries and wages, Francois and Nelson (2001, 2004) analyze both trade and foreign direct investment between similar countries, and its effect on the wage premium. The recent book by Dluhosch (2000) and the paper by Burda and Dluhosch (2001) emphasize outsourcing and relative wages.

3. STRUCTURAL IMPACT INDEXES

The basic approach to ex-ante assessment (in a developed or developing country context) involves the application of a partial or general equilibrium simulation model. (See Francois and Reinert 1997). The next section provides an example, where we employ a number of indexes for tracking the structural impact of policy changes on economy-wide employment and output patterns. For the example, these are defined with respect to the n sectors in an applied general equilibrium model, though they could also be defined with respect to the population of firms within a sector (if we had the data and estimates of within-sector production and output variation). The first index is simple, representing percent changes in output at the sector level:

$$(1) \quad I_{1,j} = \frac{dQ_j}{Q_j} \cdot 100$$

sector output change index

In equation (1), Q_i is physical output in sector i . The next two indexes are based on our measurement of output changes. These are basically variance-based indexes of our sector output deviation measure I_1 , both un-weighted $\mathbf{s}(I_1)$ and weighted $\tilde{\mathbf{S}}(I_1)$.

$$(2) \quad I_2 = \mathbf{s}(I_1) = \left\{ \left(\frac{1}{n-1} \right) \left[\sum_{j=1}^n \left(I_{1,j} - \left(\frac{1}{n} \right) \sum_{i=1}^n I_{1,i} \right)^2 \right] \right\}^{1/2}$$

un-weighted output deviation index

$$I_3 = \tilde{\mathcal{S}}(I_1) = \left\{ \left(\frac{1}{n-1} \right) \left[\sum_{j=1}^n \left(\mathbf{w}_j I_{1,j} - \left(\frac{1}{n} \right) \sum_{i=1}^n \mathbf{w}_i I_{1,i} \right)^2 \right] \right\}^{1/2}$$

(3)

$$\text{where } \mathbf{w}_i = n \cdot VA_i \cdot \left[\sum_{j=1}^n VA_j \right]^{-1}$$

weighted output deviation index

As noted above, n is our index defined over sectors. We then follow with a measure of the change in economy-wide employment earnings I_4 .

$$I_4 = \left\{ \left[\frac{\sum_{i=1}^n W_{i,1}}{\sum_{j=1}^n L_{j,1}} \right] \cdot \left[\frac{\sum_{m=1}^n W_{m,0}}{\sum_{v=1}^n L_{v,0}} \right]^{-1} - 1 \right\} \cdot 100$$

(4)

average wage index

Next, we work in the example with a set of measures of the change in employment across sectors and across the economy. These are built on the change in employment at the sector level I_5 .

$$I_{5,j} = \frac{dL_j}{L_j} \cdot 100$$

(5)

sector employment change index

Based on I_5 , we also work with two variance-based indexes, an un-weighted index $\mathcal{S}(I_5)$ and a weighted index $\tilde{\mathcal{S}}(I_5)$. (Wage bills are used as weights, as this information is usually available. Of course, other weights, such as full-time equivalent jobs, could also be used).

$$(6) \quad I_6 = \mathbf{s}(I_5) = \left\{ \left(\frac{1}{n-1} \left[\sum_{j=1}^n \left(I_{5,j} - \left(\frac{1}{n} \sum_{i=1}^n I_{5,i} \right) \right)^2 \right] \right)^{1/2} \right\}$$

un-weighted employment deviation index

$$(7) \quad I_7 = \tilde{\mathbf{s}}(I_6) = \left\{ \left(\frac{1}{n-1} \left[\sum_{j=1}^n \left(\mathbf{f}_j I_{6,j} - \left(\frac{1}{n} \sum_{i=1}^n \mathbf{f}_i I_{6,i} \right) \right)^2 \right] \right)^{1/2} \right\}$$

$$\text{where } \mathbf{f}_i = n \cdot W_i \cdot \left[\sum_{j=1}^n W_j \right]^{-1}$$

weighted employment deviation index

Finally, we also focus (where appropriate given model assumptions) on the change in total employment, as indexed by I_8 .

$$(8) \quad I_8 = \left\{ \left[\frac{\sum_{i=1}^n L_{i,1}}{\sum_{j=1}^n L_{j,0}} \right] - 1 \right\} \cdot 100$$

total employment index

Collectively, the indexes in equations (1) to (8) provide some indication of changes in the pattern of production and employment across sectors. No one of them really provides an adequate picture (as will be seen in the numeric example), though together they do provide some sense of the direction and desirability of relative changes induced by policy. This will be illustrated in the next section.

4. AN EXAMPLE

We now turn to a computational example to highlight the use and interpretation of the structural impact indexes defined above. This involves a large multi-region CGE model. The model includes monopolistic competition in industrial and service sectors as developed above. It also includes sluggish mobility of labour, as described in the annex. The experiment involves the pending enlargement of the EU, and its impact on the transition economies of Central and Eastern Europe. However, the reader should not take the results too seriously, but should instead focus on the pattern of variation in results and the apparent information content of various measures.

4.1 THE MODEL

The model is a multi-sector general equilibrium model, characterized by intermediate linkages and monopolistic competition. It is a version of the GTAP model (Hertel 1996), modified to include imperfect competition exactly as developed in the annex. (See Francois 1998). This means that Armington trade in industrial and service sectors, a feature of the standard GTAP model, is replaced with monopolistic competition. The Hertel and Francois papers provide full documentation on the theory and implementation of the model.⁶

Like most CGE models, this one is characterized by an input-output structure that explicitly links industries in a value added chain from primary goods, over continuously higher stages of intermediate processing, to the final assembling of goods and services for consumption. Inter-sectoral linkages are direct, like the input of steel in the production of transport equipment, and indirect, via intermediate use in other sectors. CGE models capture

⁶ Note that there is a long history of including monopolistic competition in CGE models. Hence, under a different name, some CGE modellers have been working with "new geography" models since the early 1980s. See Francois and Roland-Holst (1997) on this point.

these linkages by modelling firms' use of factors and intermediate inputs. The most important aspects of the model used here are the following: (i) it covers all world trade and production; and (ii) it allows for scale economies and imperfect competition. Consumer demand is generated from a representative regional household with Cobb-Douglas preferences over sectoral composites. This is a departure from the standard GTAP specification of demand.

The multi-region model used here divides the world into sixteen regions: Germany (DEU), France (FRA) , the Netherlands (NED), the rest of the EU (REU15), the recently confirmed candidate countries (CEECs), the Mediterranean economies (MED), North America (NAM), South America (SAM), China (CHINA), India (INDIA), high income Asia-Pacific economies (HINCPAS), other Asia-Pacific (OASPAC), Australia and New Zealand (AUSNZ), South Africa (SAF), Sub-Saharan Africa (SSA), and the rest of the world (ROW). Each region is modelled with 17 sectors: cereals (CERE), horticulture (HORT), sugar (SUGA), intensive livestock (INTLIV), cattle (CATLE), dairy products (DAIRY), other agriculture (OAGR), processed foods (PROCF), textiles and clothing (TEXT), extraction and mining (EXTR), chemicals and petrochemicals (CHEM), machinery and electrical machinery (MELE), other industry (OIND), trade services (TRAD), transport services (TRAN), business services (BSVC), and other services (OSVC). Each sector consists of differentiated products, and consumer and firm demand for these are generated by CES preferences. Government services are produced through a Cobb-Douglas technology, which means that government expenditure shares over product categories are fixed. Consumption is defined as a Cobb-Douglas composite of private and government consumption.

Scale economies and monopolistic competition are modelled in manufacturing and services, exactly as developed in the annex. In particular, based on evidence of scale economies (Martins et al 1996), we model sectors as being characterized by Chamberlinian

large-group monopolistic competition for traded intermediate and final goods. Other sectors (primary products and agriculture) are characterized by constant returns and perfect competition, with output differentiated by regions (the Armington assumption). Formally, factors are combined according to a CES function, while intermediates are used in fixed proportions. Both approaches (Armington and monopolistic competition) have two significant ramifications: (i) intermediate input prices enters firms' cost functions, so price-raising trade barriers directly affect firms' costs, and (ii) firms' demands for each variety of intermediates, whether differentiated by region (Armington assumption) or firm (monopolistic competition) follows standard CES derived demand functions. With product differentiation in all sectors, the model supports two-way trade in all traded sectors. Trade and scale elasticities are reported in Table A1.

The cost of trade is modelled explicitly as consisting of a combination of trade and transport services. Revenue from non-frictional trade barriers are returned to the representative consumer in each region. This includes quota rents, which are generally modelled as accruing to exporters. Regional labour and capital supplies are assumed to be fixed. (Capital is held fixed so that we can focus on resource shifts, without the additional complication of resource accumulation.)

With the exception of substitution and scale elasticities, which are drawn from the literature, model parameters are calibrated to social accounting data from the 2002 revision of the Global Trade Analysis Project (GTAP) version 5.2 data base. The GTAP dataset includes information on national and regional input-output structure, bilateral trade flows, final demand patterns, and government intervention, and is benchmarked to 1997. Bilateral tariff data are based on World Bank and WTO data on post-Uruguay Round protection, and reflect differential bilateral weighting of detailed trade data within model sectors. In addition, a stylized version of Agenda 2000 is also imposed on the benchmark database.

4.2 THE EXPERIMENT

Our experiment involves (1) a reduction in frictional trading costs between the European Union and the CEECS, corresponding to 2 percent of the value of trade; (2) free agricultural trade and harmonization of all border measures; (3) extension of the CAP subsidy scheme, with subsidies at 25% of EU15 rates. It does not include capital market effects (see Baldwin et al 1996), since at this point in time these are most likely reflected already in expectations, and hence in the base data. Some sensitivity analysis is offered vis-à-vis the mobility of labour between sectors. This is captured by a parameter (technically an elasticity of transformation) as discussed in the annex.

We introduce two labour market closures. In the first, labour markets are flexible, and employment is fixed in aggregate for skilled and unskilled labour. In the second, wages are fixed in Europe (the EU and the CEECs), while employment adjusts. Taken together, these provide some bound on the likely set of wage and employment effects.

4.3 RESULTS (STRUCTURAL IMPACT)

What are the results of our experiment? The basic results are summarized in Tables 1 and 2 and Figures 1 and 2. These are based on the index measurements defined in equations (1) to (8). The basic pattern of results is similar with both rigid and flexible labour markets, at least on the output side. However, if one examines the results closely, on the employment side the effects are rather different. First, in Table 1, we have a contraction in the processed foods sector, other industry, and agriculture. The food and agriculture results follow from forcing harmonization of external border measures, while allowing subsidies in the EU15 for agriculture at a rate 300 percent above the rate in the CEECs. (This reflects the actual Enlargement, where the CEECs receive only a fraction of comparable EU15 CAP subsidies,

even as external measures are harmonized.) There is also a dramatic expansion of textile and clothing production relative to the benchmark. We also have a dramatic increase in real wages, and a rise in the wages for unskilled workers relative to skilled workers.

Insert Tables 1, 2, Figures 1,2 about here.

What about adjustment costs? Our best approximation is the measures of deviation in output and employment. Here, Table 1 shows that the un-weighted index places excess weight on small sectors. When we introduce weighting, the apparent shifting of labour across sectors is reduced, with a standard deviation around 7 percent of employment rather than 9 percent. This is still a large number. The actual amount of labour displacement hinges on the ease with which workers are moved between sectors. In the flexible wage scenario, added mobility buys more worker movement between sectors, and in turn a greater efficiency gain and higher average wages. This comes at a price, however, as illustrated in Figure 1. Greater labour market flexibility, in this sense, buys greater wages at the cost of greater worker displacement.

The same pattern appears to hold in Figure 2, which is based on the rigid wage model results reported in Table 2. Again, we see an apparent trade-off between job creation and the general degree of labour flexibility. *However*, this is actually misleading. If we examine the raw employment numbers in Table 2, we can see that a good deal of the “churn” in the labour market involves new entrants (or re-entrants). In fact, roughly three-quarters of the volatility is associated with simple expansion. Increased flexibility, in a positive environment, yields much more rapid job growth than less flexible markets, with job growth far outpacing displacement.

The differences in Tables 1 and 2 highlight the importance of viewing indicators of this type collectively, rather than individually. Labour displacement may not be what it first appears, just as sector effects, uncontrolled for sector size, may be misleading with respect to adjustment pressures.

5. CONCLUSIONS

This paper is concerned with metrics used for the measurements of the output and employment effects of trade and trade policy, and their implications for assessing adjustment costs and the sustainability impact of policy. The paper provides both a broad-brush overview of the literature on ex-post assessment, and a discussion of ex-ante measurement. Ex-ante measurement is illustrated with a CGE application involving a stylized EU enlargement.

The econometric literature, based on the historic experience of OECD economies, stresses a number of issues. These include the displacement of labour within as well as between sectors, transition dynamics, cross-border outsourcing, and natural labour force turnover. These map directly into the determination of the adjustment costs of policy changes, though they are likely to miss important issues (like market fragmentation and rigidities) especially important in developing countries. A similar set of issues is highlighted in the computational model-based simulation literature. Unfortunately, the measures available from computational exercises don't actually touch on several of the issues stressed in the literature on actual experience. In simulation models, we do not usually have the data or structure needed to model within sector (i.e. sector-specific) labour market churn. Neither do we offer an adequate treatment of outsourcing mechanisms. "Transition dynamics" is synonymous with investment processes rather than labour force movements in the computational literature. And while labour mobility and natural turnover clearly matter, we

don't know enough yet to treat these issues adequately either. In short, we need more research.

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Annex: scale economies and labour mobility in the model

This annex is concerned with critical structural features of the CGE model used in Section 5 to illustrate the use of structural impact indexes. This includes representation of scale economies, labour mobility, and basic model parameters.

A.1 VARIETY SCALING

We start with a representation of trade under monopolistic competition that involves "variety-scaled" rather than physical output. This approach buys us a great deal of analytical simplicity when we turn to stability properties and the scope for inter-sectoral adjustment. Differentiated goods may be differentiated consumer goods, or producer goods that are assembled before the final good is sold locally. In either interpretation, there will be variety-related benefits to location. These benefits are further magnified in the computational section of the paper, where we also add intermediate linkages, reinforcing the advantages of location.

We first assume that individual firms producing variety x_j of good X are monopolists working under a homothetic cost function defined over an input price vector ω and subject to a fixed cost and constant marginal cost. Free entry forces the standard average cost pricing solution, alongside the monopoly mark-up rule. The elasticity of σ is derived from standard S-D-S preferences, and hence is a constant value σ (which also equals the elasticity of substitution). Formally, in the X sector, we have the following cost and price relationships:

$$(A1) \quad C(x) = [\mathbf{a} + \mathbf{b} \cdot x] \cdot f(\mathbf{w})$$

$$(A2) \quad P \cdot \left[1 - \frac{1}{\mathbf{s}} \right] = \mathbf{b} \cdot f(\mathbf{w})$$

$$(A3) \quad P = \left[\frac{\mathbf{a}}{x} + \mathbf{b} \right] \cdot f(\mathbf{w})$$

In equations (A1)-(A3), P denotes price, $C(\cdot)$ denotes total cost for the firm producing x , and $f(\omega)$ is the linear homothetic cost function for a bundle of inputs (designated Z below). Taken together, equations (A2) and (A3) mean that firms are of an identical size (we have a symmetric equilibrium), and that change in industry scale will be proportionate to change in the number of varieties in the industry. In particular, we will have:

$$(A4) \quad x = \frac{\mathbf{a} \cdot (\mathbf{s} - 1)}{\mathbf{b}}$$

$$(A5) \quad P = \frac{\mathbf{b} \cdot f(\mathbf{w}) \cdot \mathbf{s}}{(\mathbf{s} - 1)}$$

The scale of individual firms will be fixed, while the equilibrium price for each individual variety will be a linear function of the cost of input bundle Z . The demand for individual varieties follows from the standard S-D-S aggregation function:

$$(A6) \quad q = \left[\sum_{i=1}^n g \cdot x_i^r \right]^{1/r}$$

In equation (A6), the term g denotes a constant applied to each variety. The elasticity of substitution of substitution will be $\sigma=1/(1-\rho)$, where $0<\rho<1$. For the moment, assume that we have two sources of varieties, designated 1 and 2. These sets of varieties originate in different countries. We will maintain the large group assumption throughout (i.e. demand elasticities remain unchanged), but now we subdivide equation (A6) to reflect the split sourcing of varieties. Note that, as long as we maintain the assumption of symmetry across firms from source 1 and 2, then we will consume identical quantities over all source r varieties.

$$(A7) \quad q = \left[n_1 \cdot g_1 \cdot x_1^r + n_2 \cdot g_2 \cdot x_2^r \right]^{1/r}$$

In equation (A7), the subscript now designates (identical) varieties from a given national source, and n_r denotes the number of varieties associated with that source. Note that we have a CES weight that applies identical across varieties from a given source. We next modify equation (A7) so that it is defined over aggregate physical quantities (i.e. $X=nx$).

$$(A8) \quad q = \left[n_1^{1-r} \cdot g_1 \cdot X_1^r + n_2^{1-r} \cdot g_2 \cdot X_2^r \right]^{1/r}$$

If we hold variety constant, then equation (A8) is operationally identical to an Armington aggregation function. We will next write equation (A8) purely in terms of variety-scaled quantities V , so that we can simplify the demand side of the model by specifying it in terms of variety-scaled output. This involves one last rearrangement of equation (A8).

$$(A9) \quad q = \left[g_1 \cdot V_1^r + g_2 \cdot V_2^r \right]^{1/r}$$

$$(A10) \quad V_i = n_i^{1-r} \cdot X_i$$

On the demand side, we will work directly with equation (A9). Variety effects are embodied in the variety-scaled quantity defined by equation (A10), which we will treat as a supply-side phenomenon. Written in this way, variety works like a regional quality or scale effect that is realized at the industry level.

We turn next to the supply side of the model. We focus on sectoral output to start, but will later embed this structure into a multi-sector framework. On the supply side, assume that in country i bundles Z_i are available for production of varieties x_i of good X . From equation (4), we then have the following:

$$(A11) \quad n_i = \frac{Z_i}{2 \cdot \mathbf{a}_i \cdot (\mathbf{s} - 1)}$$

$$(A12) \quad X_{iT} = \frac{Z_i}{\mathbf{a}_i \cdot \mathbf{b}_i}$$

where X_{iT} represents total physical production of X in country i. Because expansion of the X sector involves entry of identically sized firms, both physical output and variety are linear in input of bundles Z. Putting these two terms together with equation (A10), we can derive the implicit sectoral production function for variety-scaled output V.

$$(A13) \quad V_{iT} = \frac{2 \cdot \mathbf{a}_i \cdot (\mathbf{s} - 1)^{\frac{r-1}{r}}}{\mathbf{a}_i \cdot \mathbf{b}_i} \cdot Z_i^{1/r}$$

or to simplify

$$(A14) \quad V_{iT} = A \cdot Z_i^{1/r} = \Theta(Z_i)$$

Taken together, equations (A9) and (A14) let us simplify (in a useful way) the mathematics of production and trade with specialization-based returns to scale. Basically, sectoral demand is CES and defined over variety-scaled quantities from all sources, while sectoral supply of variety-scaled varieties exhibits a form of external scale economies common in the literature. Our representation of the model works, in reduced form, like a standard Armington model with external scale economies. Working with Armington-type quantities helps in isolating the stability properties of this class of models, and their sensitivity to factor mobility issues.

A.2 THE SUPPLY SIDE: STABILITY AND THE SCALE OF LOCAL ADJUSTMENT

We now want to embed the production side of the model into a general equilibrium framework. This will allow us to explore, analytically, the relationship between local agglomeration effects (due to variety) and the adjustment of output to price shocks. To do this, we assume a transformation technology between bundles Z and a homogeneous good Y. Factor markets are assumed competitive, so that the price of Z will correspond to the marginal rate of transformation between Z and Y.

Furthermore, because we have average cost pricing vis-à-vis equation (A14), we can also map the supply-side price of V directly to the price of Z, and hence to the supply response in V and Z as we move along the production possibility frontier.

Our transformation technology, in reduced form, is represented as follows:

$$(A15) \quad Y_i = \mathbf{g}_i(Z_i) \quad \mathbf{g}' < 0, \mathbf{g}'' < 0$$

The price of bundles will be the following:

$$(A16) \quad \frac{P_{Z_i}}{P_{Y_i}} = \frac{f(\mathbf{w})_i}{P_{Y_i}} = -\mathbf{g}'$$

Average cost pricing means that we will also have

$$(A17) \quad P_{V_i} = Z_i^{1-1/r} \cdot P_{Z_i} = -\mathbf{g}' \cdot Z_i^{1-1/r} \cdot P_{Y_i}$$

Making a substitution of (A17) into (A16) and solving for percent changes, we can derive the following.

$$(A18) \quad \hat{P}_{V_i} - \hat{P}_{Y_i} = Z_i \cdot \left[\frac{\mathbf{g}''}{\mathbf{g}'} - \frac{\Theta''}{\Theta'} \right] \cdot \hat{Z}_i$$

Equation (A18) relates changes in equilibrium supply of Z to changes in the relative prices of V and Y. The first term captures the relative curvature of the production possibility frontier (defined over bundles and Y), while the second term captures the relative curvature of the Θ function, which depends on variety effects. In a constant returns to scale model, the second term vanishes, and we simply have a variation of the classic Jones-type equation relating changes in supply to changes in

relative prices. In the present setting, however, the presence of variety-specialization effects complicates the analytical mix.

Consider the case where we have local stability (in the sense that the sign of equation (A18) is positive). For a policy shock ultimately manifested, at least to producers, as a shift in producer prices, the corresponding magnitude of the shift in output will depend on how strong the scale effect is, as transmitted through the Θ function. The stronger it is, the greater the output response associated with a given price change, if equation (A17) is to hold. In other words, even for local adjustment from one stable equilibrium to another, how local such adjustment to a price shock will actually be will depend on the magnitude of scale effects. The larger the scale effects, the greater the corresponding shift in resources associated with an observed shift in relative prices. Of course, if the sign of equation (A18) is negative, then the local equilibrium is unstable, with a well-known potential for corner solutions (Francois and Nelson 2002).

A.3 FACTOR MOBILITY AND OUTPUT ADJUSTMENT

We now turn to the issue of local adjustment, and the role of factor mobility. By factor mobility, we are not referring to cross-country movement of factors. While this is an important theme in the recent geography literature and older scale economy literature (Krugman and Venables 1995; Markusen 1988; Rivera-Batiz and Rivera-Batiz 1991), our concern instead is the ability of factors (and in particular labour) to move between sectors within a country as employment opportunities shift. In terms of equation (A18), the inter-sectoral mobility of labour can be examined through its impact on the curvature of the γ function.

To develop this issue further, we will impose more structure on the γ function. In particular, we follow the older literature on inter-sectoral factor mobility (see for example Casas 1984; Hertel and Tsigas 1996) and assume that a constant elasticity of transformation will characterize our ability to shift resources between the Z and Y sector. In generic terms, this may follow from underlying differences in technology across sectors, as well as from factor mobility. However, for the moment, we focus on factor mobility.

Formally, the γ function that can be derived from a CET is represented as follows:

$$(A19) \quad Y = \mathbf{g}(Z) = \left[\frac{Q^f}{a} - \frac{b}{a} \cdot Z^f \right]^{1/f}$$

In equation (A19), the term $\phi > 1$, and we will have an elasticity of substitution along the ZY frontier that is concave to the origin, and characterized by a constant elasticity or transformation $\Omega = 1/(\phi - 1)$, where $1 < \Omega \leq \infty$. With an infinite transformation elasticity, the transformation frontier is linear.

Given equations (A14) and (A19), equation (A18) then can be written as follows:

$$(A20) \quad \hat{P}_{vi} - \hat{P}_{yi} = Z_i \cdot \left[\left\{ (f - 1) \cdot (1 + Z^f \cdot (b/a)) \right\} + \{1 - 1/r\} \right] \cdot \hat{Z}_i$$

The first term in brackets $\{ \}$ captures the curvature of the CET, through the parameter ϕ and our location on the transformation frontier, while the second term captures variety scaling effects.

Note that in the large group case, with homothetic cost functions, the variety-scaling term is actually a constant, so that local stability ends up depending entirely on variations in the curvature of the transformation frontier. This actually characterizes much of the recent literature, which employs Ricardian single factor models (i.e. linear transformation surfaces). In effect, this approach assumes, in reduced form, that corner solutions will be highly likely, along the lines of Kemp's (1964) work on Ricardian models with external scale economies.

In the body of the paper, we employ equation (A19), in a multi-sector general equilibrium model including intermediate linkages and monopolistic competition (a.k.a. a computational geography model) with a range factor mobility values.

A.4 Model Parameters

Model parameters are listed below. The model is as described in Hertel and Tsigas (1996) and Francois (1998). CDRs are used to calibrate output-scale elasticities for variety-scaled output.

Table A1
Model Parameters

		A	B	C	D = (B-1)/B	E = 1/D
		trade substitution elasticities (regional differentiation)	average markup levels	elasticity of substitution in value added	implied CDRs	trade substitution elasticity (firm differentiation)
CERE	Cereals	2.200	1.000	0.246	0.000	2.200
HORT	Horticulture & other crops	2.200	1.000	0.246	0.000	2.200
SUGA	Sugar, plants and processed	2.200	1.000	0.639	0.000	2.200
INTLIV	Intensive livestock & products	2.497	1.000	0.545	0.000	2.497
CATLE	Cattle & beef products	2.453	1.000	0.571	0.000	2.453
DAIRY	Milk & dairy	2.200	1.000	0.645	0.000	2.200
OAGR	Other agriculture	2.754	1.000	0.203	0.000	2.754
PROCF	Processed food products	2.472	1.125	1.120	0.111	8.983
TEXT	Textiles, leather & clothing	3.316	1.126	1.260	0.112	8.909
EXTR	Extraction industries	2.800	1.177	0.200	0.151	6.638
CHEM	Petro & chemicals	2.050	1.200	1.260	0.167	6.005
MELE	Metal and electotechnical ind	3.386	1.212	1.260	0.175	5.720
OIND	Other industries	2.299	1.202	1.260	0.168	5.946
TRAD	Trade services	1.900	1.273	1.680	0.214	4.670
TRAN	Transport services	1.900	1.273	1.680	0.214	4.670
BSVC	Business, financial & commun. services	1.900	1.273	1.260	0.214	4.670
OSVC	Other private and public services	1.975	1.273	1.286	0.214	4.670

Figure 1

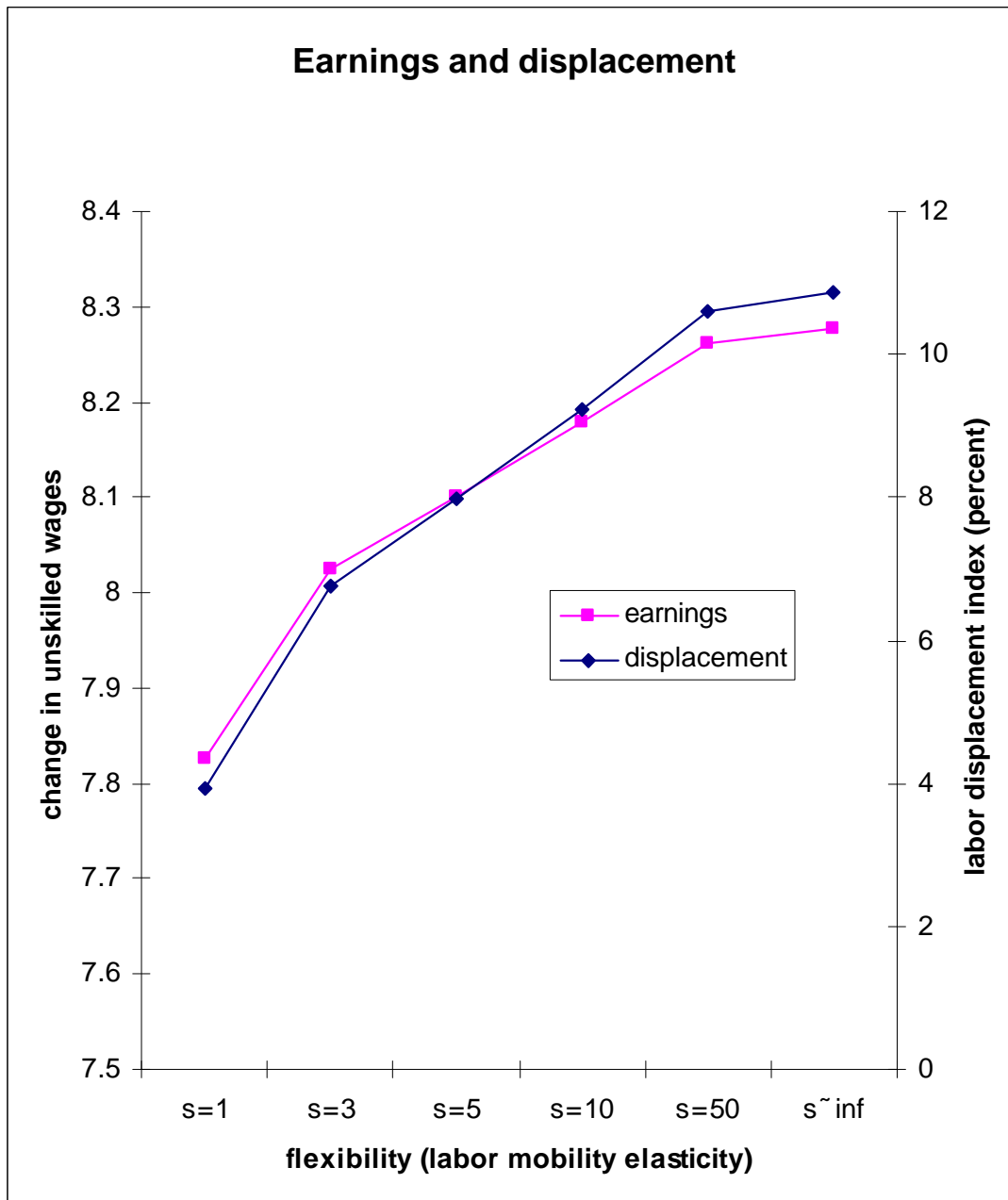


Figure 2

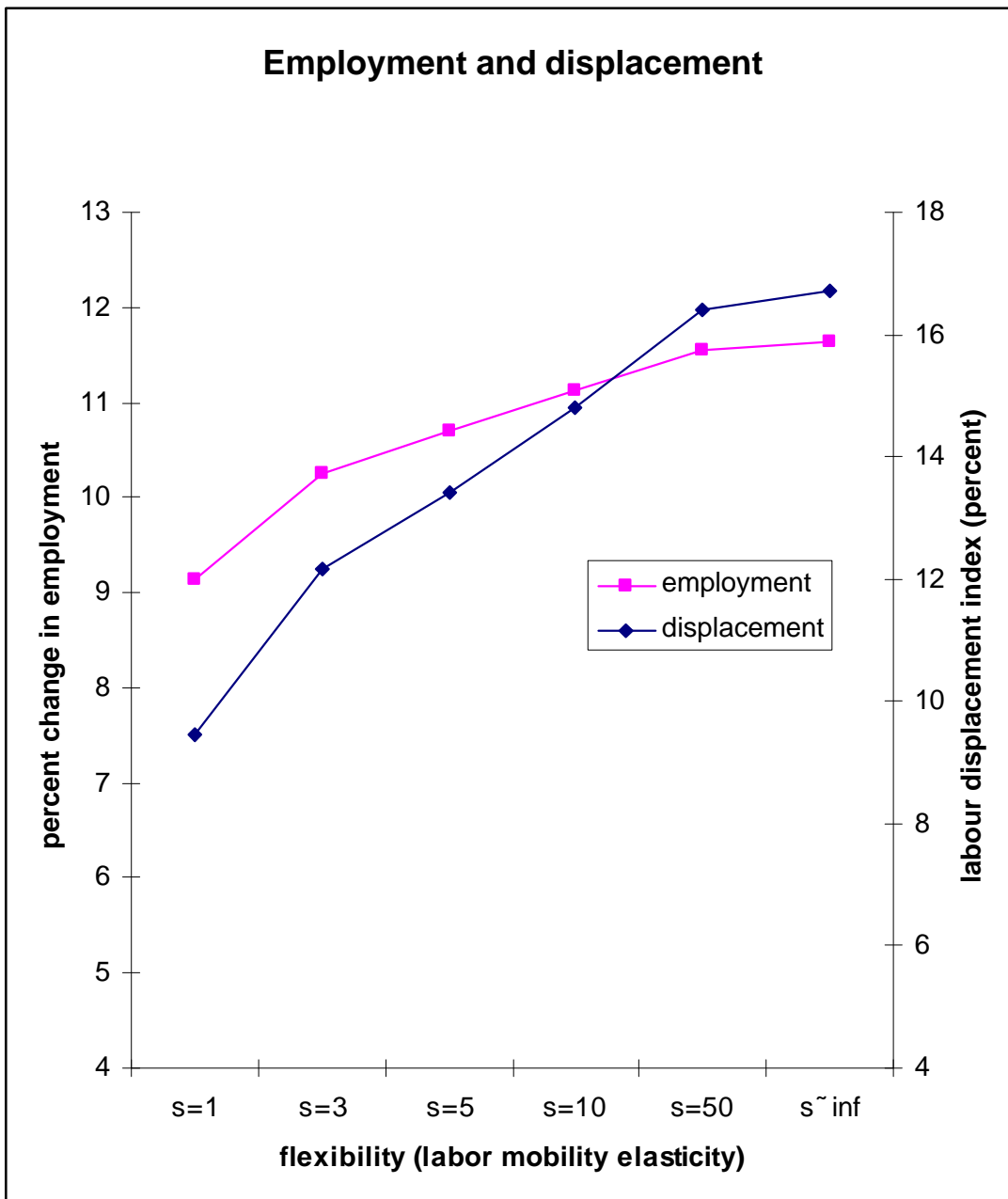


Table 1

Fixed Employment, Flexible Wages

		? ----- low		LABOR MOBILITY		high -----?	
equation		s=1	s=3	s=5	s=10	s=50	s~ inf
	<i>Production Effects</i>						
(1)	Percent changes in sector output						
	Cereals	-1.99	-2.71	-2.99	-3.27	-3.56	-3.62
	Horticulture & other crops	-3.25	-3.95	-4.20	-4.44	-4.68	-4.72
	Sugar, plants and processed	4.30	3.54	3.20	2.85	2.48	2.40
	Intensive livestock & products	-0.44	-0.76	-0.88	-1.00	-1.12	-1.14
	Cattle & beef products	4.44	4.61	4.65	4.67	4.68	4.68
	Milk & dairy	3.04	3.11	3.12	3.12	3.12	3.11
	Other agriculture	-0.91	-1.28	-1.42	-1.57	-1.71	-1.74
	Processed food products	-8.23	-10.47	-11.36	-12.25	-13.17	-13.35
	Textiles, leather & clothing	15.06	21.91	24.96	28.23	31.83	32.55
	Extraction industries	-0.41	-0.61	-0.69	-0.77	-0.86	-0.88
	Petro & chemicals	1.12	1.11	1.11	1.10	1.09	1.09
	Metal and electrotechnical ind	6.00	6.82	7.03	7.16	7.24	7.24
	Other industries	-3.77	-4.81	-5.25	-5.69	-6.15	-6.25
	Trade services	-0.83	-0.95	-1.01	-1.06	-1.12	-1.14
	Transport services	2.21	2.02	1.91	1.79	1.64	1.60
	Business, financial & communications services	-2.05	-2.35	-2.47	-2.59	-2.71	-2.73
	Other private and public services	-1.02	-1.23	-1.31	-1.38	-1.45	-1.47
(2)	Un-weighted output deviation index	5.06	6.76	7.51	8.31	9.20	9.38
(3)	weighted output deviation index	4.40	5.68	6.22	6.80	7.43	7.55
	<i>Employment Effects</i>						
(4)	Unskilled wages (average change)	7.83	8.02	8.10	8.18	8.26	8.28
(4)	Skilled wages (average change)	6.37	6.54	6.61	6.67	6.73	6.75
(6)	Unweighted employment deviation index -- unskilled	3.52	5.90	6.93	8.01	9.21	9.45
(6)	Unweighted employment deviation index -- skilled	3.60	6.05	7.11	8.24	9.48	9.73
(7)	Weighted employment deviation index -- unskilled	3.94	6.77	7.97	9.23	10.60	10.88
(7)	Weighted employment deviation index -- skilled	2.14	3.48	4.00	4.53	5.09	5.20

Table 2

Flexible Employment, Fixed Wages

		? ----- low		LABOR MOBILITY		high -----?	
equation		s=1	s=3	s=5	s=10	s=50	s~ inf
	<i>Production Effects</i>						
(1)	Percent changes in sector output						
	Cereals	1.95	1.34	1.11	0.89	0.66	0.62
	Horticulture & other crops	0.57	-0.12	-0.33	-0.54	-0.73	-0.76
	Sugar, plants and processed	8.53	8.01	7.77	7.50	7.22	7.17
	Intensive livestock & products	3.37	3.17	3.11	3.06	3.02	3.02
	Cattle & beef products	8.55	8.96	9.10	9.23	9.36	9.39
	Milk & dairy	7.08	7.43	7.55	7.68	7.81	7.83
	Other agriculture	2.45	2.25	2.20	2.14	2.09	2.08
	Processed food products	-3.87	-5.97	-6.83	-7.69	-8.59	-8.77
	Textiles, leather & clothing	23.34	32.68	36.85	41.32	46.29	47.28
	Extraction industries	1.86	1.42	1.28	1.16	1.03	1.00
	Petro & chemicals	5.01	5.44	5.59	5.75	5.91	5.94
	Metal and electrotechnical ind	11.13	12.53	12.92	13.22	13.45	13.48
	Other industries	0.54	-0.03	-0.30	-0.59	-0.91	-0.97
	Trade services	2.83	3.29	3.46	3.63	3.79	3.83
	Transport services	6.05	6.43	6.53	6.60	6.65	6.66
	Business, financial & communications services	1.39	1.60	1.68	1.74	1.81	1.82
	Other private and public services	3.34	3.56	3.65	3.74	3.83	3.85
(2)	Un-weighted output deviation index	5.98	8.21	9.21	10.28	11.47	11.71
(3)	weighted output deviation index	5.85	7.35	8.01	8.71	9.49	9.65
	<i>Employment Effects</i>						
(8)	Unskilled employment (economywide change)	9.14	10.26	10.69	11.11	11.56	11.64
(8)	Skilled employment (economywide change)	7.48	8.37	8.73	9.08	9.45	9.52
(6)	Unweighted employment deviation index -- unskilled	4.63	7.66	9.00	10.44	12.04	12.37
(6)	Unweighted employment deviation index -- skilled	4.45	7.54	8.91	10.39	12.03	12.36
(7)	Weighted employment deviation index -- unskilled	9.46	12.15	13.42	14.81	16.40	16.72
(7)	Weighted employment deviation index -- skilled	15.70	16.76	17.24	17.76	18.33	18.44