**6202 European Commission**
**DG Internal Market**

# Market Opening in Network Industries
## Part I: Final Report

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# Preface

This is the final report of the study “Market Opening in Network Industries”. The report has been prepared by a team lead by Dr. Claus Kastberg Nielsen as project leader. The team members have been Mr. Christian Jervelund, Mr. Patrik Svensson, Mr. Lars B. Termansen, Mr. Torkild Dalgaard and Mr. Eske Stig Hansen, all from Copenhagen Economics. The team has benefited from important input submitted by Netplan, Tetraplan and Torben Holvad from University of Oxford.

The quality assurance of this report has been undertaken by Dr. Jesper Jensen (general equilibrium modelling) and Professor Asger Lunde (econometrics) who are both affiliated to Copenhagen Economics.

September 2005

Claus Kastberg Nielsen
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# Executive summary

The objective of this study is to measure the impact on overall economic performance due to market opening in network industries in EU15 member states during the last 10-15 years. The network industries included in the study are: Electricity, telecommunication, rail passenger transport, rail freight transport, urban (passenger) transport, air (passenger) transport, natural gas, and postal services. A secondary objective is to identify those elements of market opening reforms that have been the most important drivers of the expected economic gains in each network industry.

Network industries provide crucial inputs for production in all other sectors of the economy. To the extent that market opening in network industries has indeed succeeded in increasing productivity and reducing prices, market opening is believed to posses a potential for significant spill-over effects to the rest of the economy and to significant economic gains in terms of welfare, consumption and employment

Overall, we confirm the existence of economic gains. We estimate that market opening in network industries until the turn of the century increases overall EU welfare by 1.9 percent or €98 billion and gives rise to additional employment corresponding to about 500.000 jobs. It is important to recognize that most of these gains have already been collected and incorporated into the European economy. However, the boost in economic activity has also caused an increase in emissions of greenhouse gases. We estimate that market opening in network industries has increased greenhouse gas emissions by about 4 percent.

The overall gains are for several reasons primarily associated with market opening in telecommunication and electricity. *First*, these two sectors account for almost two thirds of all output from the seven network industries covered by this study. *Second*, market opening has been faster and more penetrating here than in all other network industries. *Third*, the impact of market opening on price and productivity is by themselves larger and more significant than in other network industries

All EU15 member states have gained from market opening in network industries but with significant differences. Some member states such as Sweden and Finland, have gained noteworthy increases in welfare above 5 percent, while other member states such as Greece have hardly gained anything. These differences are primarily rooted in differences in the scope and progress of market opening in telecommunications and electricity. Those member states who opened markets *more* and who started *early* have gained the most. The latter is due to the fact that it takes some time for market opening to fully have an impact on prices and productivity.

Most of the employment gains are created in services sectors. Clearly, more jobs are created in service because service sectors constitute the major part of the economy. However, this is not the only reason. Service sectors also gain more jobs because they are the most intensive users of output from many network industries. This is in particular true for telecommunications and postal services and still true, but less so, for all transport sectors. It means that input costs shrink more for service sectors than for other sectors which can be converted into a relative cost advantage when overall demand increases.

The analytical framework employed consists of three stages and is closely related to the framework applied in Copenhagen Economics (2005). However, the framework has been adapted for the specific purposes of this study.

In the *first stage* we measure in quantitative terms the progress of market opening in EU network industries. We develop a strictly hierarchical index methodology enabling us to transform qualitative information about specific policies into quantitative information in a meaningful, transparent and - as far as possible - unambiguous way. The result is the *Market Opening Index (MOI)*. The Market Opening Index is an aggregate indicator that for a given sector, member state, and year summarises the progress of market opening on a scale between zero and unity. The index is constructed such that full market opening corresponds to unity value.

In the *second stage*, we focus on establishing a statistical link between changes in market opening as captured by the Market Opening Index (and its components) and changes in sectoral performance, primarily productivity and prices. We specify econometric models based on standard production function theory where sectoral price or productivity enters on the left hand side and market opening and other explanatory indicators on the right hand side. As we have information on market opening across time and member states, the natural econometric set-up is a panel data model.

We now have two different tasks calling for slightly different econometric approaches. First, we want to establish *significance;* that is we want to verify whether market opening is a statistically significant determinant of economic performance in EU network industries, and we want to *identify* those market opening policies (or other features of market opening) that are important drivers of sectoral economic performance. This task calls for an *exclusive* approach where we gradually squeeze out market opening milestones that explain less than others.

Second, we want to *forecast* the overall price and productivity change that has been caused by market opening and to use this forecast as an input into the simulation model to be applied in the third stage of the study. This task calls for an *inclusive* approach keeping as much information as possible as in other forecasting exercises and for a more structured estimation process enabling us to distinguish between the impact of market opening that has already arisen (in the base year of the simulation model) and the impact of market opening that may arise in the future.

Finally, in the *third stage*, we apply the forecasted price and productivity changes to compute the economy-wide impact of market opening in network industries in a simulation model called the Copenhagen Economics Trade Model. The Copenhagen Economics Trade Model is a global, multi-regional computable general equilibrium model capturing all linkages between the different sectors of the economy specifically designed for the analysis of market opening in network industries. The linkages are important, because market opening will reduce the price of network services creating significant spill-over effects in other sectors.

# Chapter 1 Market opening in EU network industries

Network industries, for example telecommunications, transport, and electricity, in EU member states have been subject to significant regulatory changes during the last decade of the past century. While the typical market in network industries previously was heavily dominated by state-owned natural monopolies, many initiatives have been launched to open these markets for the entry of new firms in order to stimulate competition and enhance efficiency.

Network industries provide crucial inputs for production in all other sectors of the economy. To the extent that market opening in network industries has indeed succeeded in increasing productivity and reducing prices, market opening is believed to posses a potential for significant spill-over effects to the rest of the economy and to significant economic gains in terms of welfare, consumption and employment.

The prime objective of this study is precisely to measure the impact on overall economic performance due to market opening in network industries in EU15 member states during the last 10-15 years. The network industries included in the study are: Electricity, telecommunication, rail passenger transport, rail freight transport, urban (passenger) transport, air (passenger) transport, natural gas, and postal services. A secondary objective is to identify those elements of market opening reforms that have been the most important drivers of the expected economic gains in each network industry.

Overall, we confirm the existence of economic gains. We estimate that market opening in network industries until the turn of the century increases overall EU welfare by 1.9 percent or €98 billion and gives rise to additional employment corresponding to about 500.000 jobs. It is important to recognize that most of these gains have already been collected and incorporated into the European economy.

The gains of market opening arise because market opening induces competition and more efficient production in network industries giving rise to lower prices on (most) network services and greater choice. Lower prices reduce the operating costs in all industries using network services and stimulate overall demand. The boost in demand creates new jobs. The boost in demand and economic activity also creates more greenhouse gas emissions. Accordingly, we estimate that market opening in network sectors has increased greenhouse gas emissions by about 4 percent.

In the future, we will most likely see further gains in welfare and employment stemming from market opening in network industries that have already been implemented before the turn of the century. The reason is that there is a time lag between implementation of market opening and its economic impact. These longer term gains may double the impact on welfare and employment from market opening in network industries, but we shall strongly emphasise that the longer term gains are considerably more uncertain than the gains already achieved and reported above.

The overall gains are for several reasons primarily associated with market opening in telecommunication and electricity. *First*, these two sectors account for almost two thirds of all output from the seven network industries covered by this study. *Second*, market opening has been faster and more penetrating here than in all other network industries. *Third*, the impact of market opening on price and productivity is by itself larger and more significant than in other network industries.

In other network industries, in particular rail freight transport and air (passenger) transport, market opening has also managed to increase productivity and reduce prices, but the overall economic impact is less comprehensive as both sectors are small compared to electricity and telecommunications.

In the remaining network industries, rail passenger transport, urban (passenger) transport, postal services and gas, it has been difficult to identify unambiguous and credible links between market opening and economic performance. There may be several reasons for this outcome. *First*, there might be no link, and market opening has not and will not give rise to better economic performance in these sectors. *Second*, market opening may lead to economic gains but has not yet been sufficiently comprehensive to release the gains. *Third*, market opening may lead to economic gains but the poor data quality prevents us from identifying the link. However, as data quality in these network industries is consistently inferior to data quality in the other industries, we tend to emphasize the third explanation.

All EU15 member states have gained from market opening in network industries but with significant differences. Some member states such as Sweden and Finland have gained noteworthy increases in welfare above 5 percent, while other member states such as Greece have hardly gained anything. These differences are primarily rooted in differences in the scope and progress of market opening in telecommunications and electricity. Those member states who opened markets *more* and who started *early* have gained the most. The latter is due to the fact that it takes some time for market opening to fully have an impact on prices and productivity.

Most of the employment gains are created in service sectors. Clearly, more jobs are created in service because service sectors constitute the major part of the economy. However, this is not the only reason. Service sectors also gain more jobs because they are the most intensive users of output from many network industries. This is in particular true for telecommunications and postal services and still true, but less so, for all transport sectors. It means that input costs shrink more for service sectors than for other sectors which can be converted into a relative cost advantage when overall demand increases.

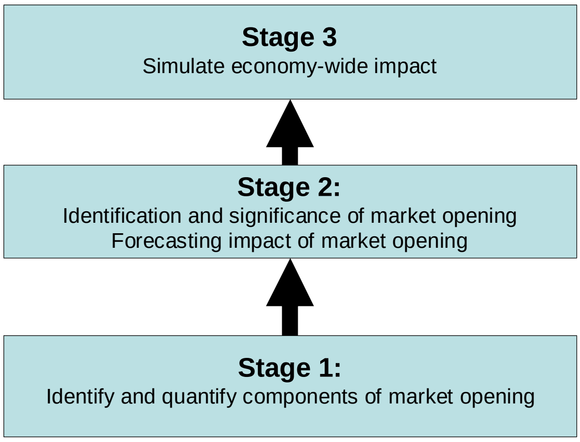
*The methodology employed*

Other studies have previously measured the economic consequences of market opening in network industries[1]. Most of these studies, if not all, have reached their goal by calculating the economic impact that is likely to arise *in the future* as the result of a hypothetical price reduction and productivity rise that are assumed to be the results of an *unspecified* market opening. This study is more ambitious. It aims to measure the economic impact that has already arisen *in the past* as the result of a *well-defined* market opening process that has already been implemented in EU15 member states in a *well-defined time period*.

[1] See Doove et al. (2001) for a summary of studies.

The analytical framework employed has been specifically developed to meet these aims. In the remainder of this chapter we provide an intuitive overview of the analytical framework that we have employed and the overall results that we have obtained. The analytical framework consists of three stages, cf. Figure 1.1, and is closely related to the analytical framework applied in Copenhagen Economics (2005). However, the framework has been adapted for the specific purposes of this study.

**Figure 1.1: Three stages in the analysis of market opening in network industries**




Source: Copenhagen Economics.

In the *first stage* we measure in quantitative terms the progress of market opening in EU network industries. We develop a strictly hierarchical index methodology enabling us to transform qualitative information about specific policies into quantitative information in a meaningful, transparent and - as far as possible - unambiguous way. The result is the *Market Opening Index (MOI)*. The Market Opening Index is an aggregate indicator that for a given sector, member state, and year summarises the progress of market opening on a scale between zero and unity. The index is constructed such that full market opening corresponds to unity value.

In the *second stage*, we focus on establishing a statistical link between changes in market opening as captured by the Market Opening Index (and its components) and changes in sectoral performance, primarily productivity and prices. We specify econometric models based on standard production function theory where sectoral price or productivity enters on the left hand side and market opening and other explanatory indicators on the right hand side. As we have information on market opening across time and member states, the natural econometric set-up is a panel data model.

We now have two different tasks calling for slightly different econometric approaches. First, we want to establish *significance;* that is we want to verify whether market opening is a statistically significant determinant of economic performance in EU network industries, and we want to *identify* those market opening policies (or other features of market opening) that are important drivers of sectoral economic performance. This task calls for an *exclusive* approach where we gradually squeeze out market opening milestones that explain less than others.

Second, we want to *forecast* the overall price and productivity change that has been caused by market opening and to use this forecast as an input into the simulation model to be applied in the third stage of the study. This task calls for an *inclusive* approach keeping as much information as possible as in other forecasting exercises and for a more structured estimation process enabling us to distinguish between the impact of market opening that has already arisen (in the base year of the simulation model) and the impact of market opening that may arise in the future.

Finally, in the *third stage*, we apply the forecasted price and productivity changes to compute the economy-wide impact of market opening in network industries in a simulation model called the Copenhagen Economics Trade Model. The Copenhagen Economics Trade Model is a global, multi-regional computable general equilibrium model capturing all linkages between the different sectors of the economy specifically designed for the analysis of market opening in network industries. The linkages are important, because market opening will reduce the price of network services creating significant spill-over effects in other sectors.

In the following sections, we summarise the key elements of the analytical framework and the results that we have obtained. In section 1.1 we explain how we measure market opening in quantitative terms and how we construct the Market Opening Index. Section 1.2 introduces the econometric set-up and identifies significant market opening policies in each network industry. Section 1.3 forecasts the impact on sectoral performance arising from market opening and section 1.4 calculates the over-all economic impact in a global simulation model.

## 1.1. Measuring market opening

Market opening implies the implementation of complex multi-dimensional policies. In order to measure market opening properly, we need to develop a methodology that enables us to transform qualitative information about specific market opening policies into quantitative information in a meaningful, transparent and - as far as possible - unambiguous way.

To meet this goal we have chosen to design an indicator measuring the extent of market opening in a network industry. We call this indicator the *Market Opening Index (MOI)*. The Market Opening Index is an aggregate indicator that for a given year, member state, and network industry summarises the progress of market opening on a scale between zero and unity.

The Market Opening Index is based on sector specific *Market Opening Milestones (MOMs)*[2]. A Market Opening Milestone is a concrete and specific policy initiative under realistic control of policy makers. For example, the Market Opening Index for the electricity sector include milestones representing the degree of retail market open for free choice, the degree of unbundling of the transmission and distribution network, third party access regimes for the distribution and transmission network, tariff structure, ownership, wholesale market model, and congestion mechanisms.

Member states achieve market opening over time by implementing an increasing number of Market Opening Milestones. When one of these milestones is implemented by a member state the value of the Market Opening Index increases in the year of implementation and in all succeeding years. We define full market opening as the implementation of a complete set of sector specific Market Opening Milestones. When all these milestones are implemented, no further policy initiatives can – in principle – lead to more market opening. The index is constructed such that full market opening corresponds to unity value.

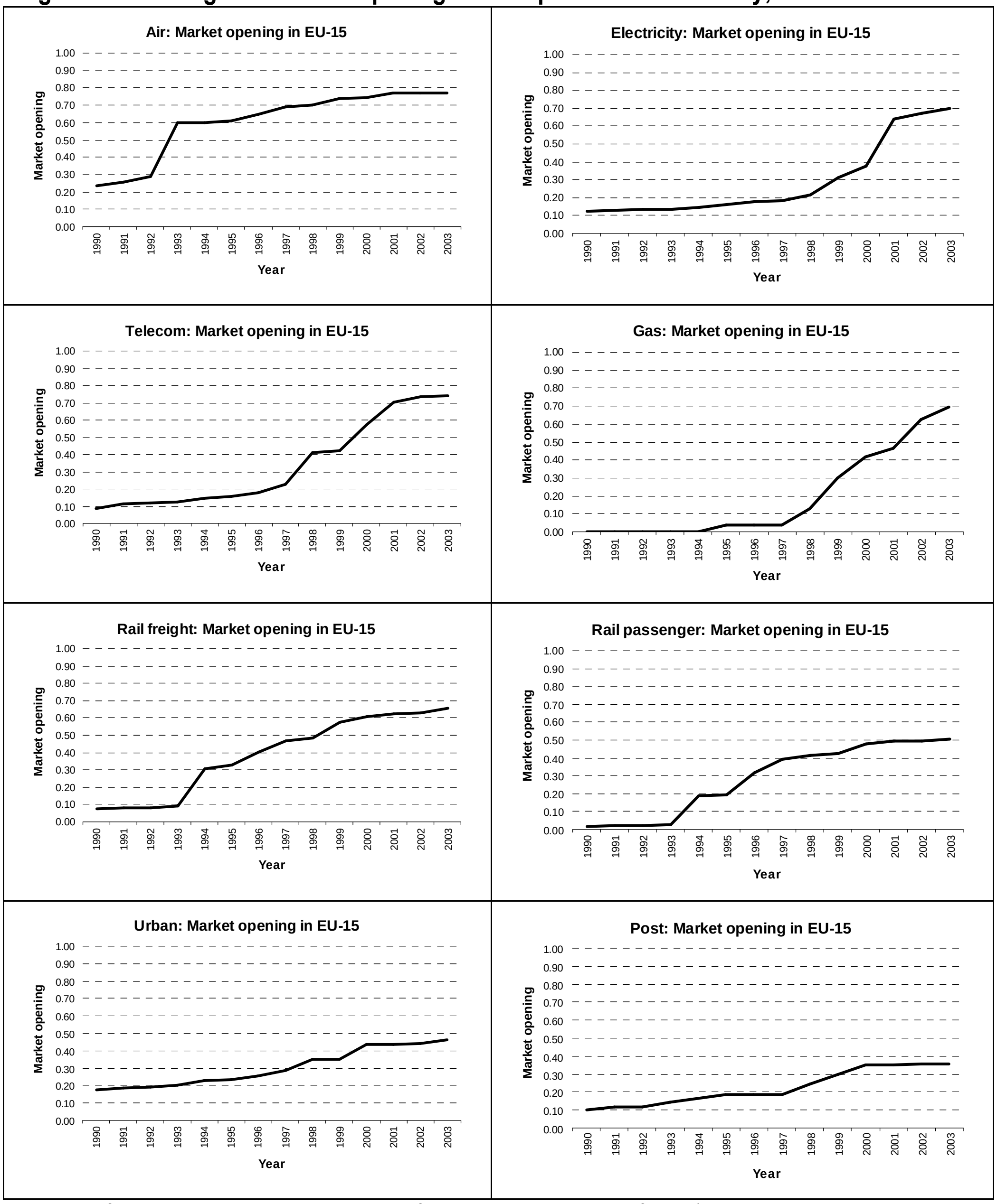
The value of the Market Opening Index in a given year is calculated as the weighted sum of the scores for all Market Opening Milestones implemented in or before a given year. A Market Opening Milestone has a zero score if the milestone has yet to be implemented by a member state and a positive score between zero and unity when it is implemented. The score is based on expert estimates of the importance of the milestone for market opening. The weight of a

[2] We have between five and twelve Market Opening Milestone for each Market Opening Index.

milestone is the guesstimated importance of the milestone relative to other milestones. Later, in the second stage of the study the weights are determined statistically.

In this way, the Market Opening Index describes for each member state the time path of market opening in a given network industry. On average EU-level the indices reveal that market opening has been most advanced in telecom, electricity, air and as a recent newcomer also gas, cf. Figure 1.2. Market opening has been less advanced in rail transport and least advanced in urban transport and in particular postal services.

**Figure 1.2: Average EU Market Opening Indices per network industry, 1990-2004**




Note: The figures illustrate average sector specific market opening indices for EU15 member states weighted by the network size in each member state. The indices may take on values from zero to one. A higher index value indicates that market opening is more advanced.
Source: Copenhagen Economics (2004), Market Opening Milestones (MOM) database

Similar indices can be constructed for each member states and for each network industry in each member state. The indices for each member state reveal that market opening in Great

Britain, Sweden, Finland and Denmark has been faster and more comprehensive than in other member states, while market opening in Luxemburg and Greece has been slow and limited.

## 1.2. Identifying significant links between market opening and sectoral performance

In the next stage, we have to establish econometrically whether significant statistical links exist between changes in market opening and changes in performance. For this purpose, we set up a suitable econometric model and systematically test for the significance of market opening as captured by the Market Opening Index or Market Opening Milestones. However, first we have to make a number of basic choices.

*Setting up the econometrics*

*First,* we have to choose a production model that can explain performance. We set up standard production functions where price or productivity enters on the left hand side as the variable to be explained and indicators of capital and labour costs, of market opening and other relevant variables enter on the right hand side as explanatory variables. We prefer to base production functions on standard Cobb-Douglas technology, because this functional form releases more degrees of freedom than other (more flexible) forms for the prime purpose of the study: The estimation of the impact of market opening.

In this model, the estimated parameter to the market opening variable measures by how much price or productivity change in percentage terms when the market opening variable changes by one unit. As the maximum value of the Market Opening Indicator is unity, the parameter also measures the maximum impact on sectoral performance of market opening. Multiplying the change in market opening in a given period by the market opening elasticity provides an estimate of the aggregate shock to sectoral prices or productivity as a consequence of market opening in the given period.

*Second,* we have to choose an econometric methodology. As we in principle have information on market opening in each network industry for most years between 1990 and 2003 and for each of the EU15 member states, the natural econometric set-up is a panel data model. A panel data model allows us to estimate the impact of market opening on sector performance assuming that the impact of a given increase in market opening differs between network industries but within that industry is the same for all member states conditional on all other explanatory variables.

Panel data analysis requires some data variation between member states in order to produce significant estimates. This is in general not a problem except for the air (passenger) transport industry where market opening has been unusually coordinated between member states. However, data availability differs significantly between industries. In some industries as electricity and telecommunication data availability is fine allowing us to produce very credible estimations. In other industries as postal services and urban transport data availability is generally poor making results more uncertain.

We estimate the panel data model using instrumental variables to take into account that variables explaining sector performance may themselves be determined by other explanatory variables in the model, that is, there might be a problem of endogeneity. We estimate the panel data model using dynamic or static representations depending on data. We have slight preference for a dynamic specification to take into account the fact that market opening in one year may (also) have an impact in the future. This is confirmed by the high auto-correlation in the residuals in a static estimation. In the dynamic representation we use advanced GMM-estimation procedures while we in the static representation employ fixed and random effect estimation procedures.

*Third,* we have to choose how to represent market opening. The Market Opening Index is a convenient tool for capturing the aggregate progress of market opening for illustrative purposes, but for the two objectives of this study the information contained in the aggregate Market Opening Index may be too limited. When identifying key drivers of market opening we need to be able to sort out the impact of individual Market Opening Milestones and cannot necessarily rely on the Market Opening Index only. When forecasting the impact of market opening we strongly prefer to base forecasts on the full information set.

The Market Opening Index reduces the number of variables in the model but severely restricts the information set. Market Opening Milestones convey a richness of information but is often marred by multi-collinearity since member states often implement different milestones simultaneously. To mitigate the advantages and disadvantages of these two choices we have also applied factor analysis. Factor analysis is a statistical technique allowing us to construct a limited number of independent variables, so-called latent factors, while on the same time keeping a very significant share of the information included in the original, but dependent, milestones. Factor analysis is appealing because it reduces the problem of multi-collinearity while at the same time preserving a large part of the variance of the Market Opening Milestones. Factor analysis and latent factors are going to play important roles in the study due to the need to control for the pervasive multi-collinearity between Market Opening Milestones.

Thus, in the econometric analysis market opening can depending on the circumstances be represented by the Market Opening Index, Market Opening Milestones, or latent factors constructed by factor analysis.

*Identification and significance*
In order to identify the key market opening drivers of sectoral performance and establish significance (if possible) we systematically test for various representations of market opening and employ elements of a general-to-specific strategy to determine the best model, the final model.

*First*, for each industry we determine whether a dynamic or static model is the more appropriate choice for a benchmark model. *Second*, we systematically test for the inclusion (or exclusion) of the Market Opening Index, the individual Market Opening Milestones, or the latent factors, including some non-linear and interacting combinations of the variables. The best of these models is the final model. We report the results from the final model. *Third*, we test a number of additional hypotheses concerning market opening. We investigate whether changes in market structure, that is actual entry of new firms on the market, is a necessary requirement for market opening to have a positive impact on sectoral performance or whether potential entry suffices. In addition, we investigate whether a strong regulatory agencies is a necessary requirement for successful market opening. Finally, we investigate whether the initial state of the network industry or the choice of reform speed or timing matters for successful market opening

The results demonstrate clear evidence of a statistically significant link between market opening and sectoral performance. In addition, in most industries the estimated parameters have the expected signs, i.e. implying that market opening leads to *lower* prices and *higher* productivity everything else equal, cf. Table 1.1. This is in particular true in large network industries with good data where market opening has been most advanced such as telecommunications, electricity, rail freight transport and air (passenger) transport. In some other smaller network industries where market opening is lagging behind and where data quality is poor, we find in some cases contra dictionary or insignificant results. This is for example urban (passenger) transport, rail passenger transport and postal services.

**Table 1.1: Sign and significance in final models, EU15 member states**

| | Prices | | | Productivity | | |
|---|---|---|---|---|---|---|
| **Sector** | Significant variable | Expected negative sign | Significance | Significant variable | Expected positive sign | Significance |
| Electricity | MOM | Yes | Yes | MOM | Yes | Yes |
| | | | | MOM | Yes | Yes |
| Urban | MOM | Yes | Yes | **MOI** | No | Yes |
| Rail (pass) | MOM | Yes | Yes | MOM | Yes | Yes |
| | | | | MOM | No | Yes |
| Rail (freight) | MOM | Yes | Yes | MOM | Yes | Yes |
| | | | | MOM | Yes | Yes |
| Telecom (fixed) | **Factor** | Yes | Yes | **MOI** | Yes | Yes |
| Air | **MOI** | Yes | No | **MOI** | Yes | Yes |
| Gas | MOM | Yes | Yes | na | na | Na |
| | MOM | Yes | Yes | | | |
| | MOM | No | Yes | | | |
| Postal services | **Factor** | Yes | Yes | **Factor** | Yes | Yes |
| | **Factor** | No | Yes | | | |

Notes: Green indicates that the estimated parameter has the expected sign and is significant. Yellow indicates that the estimated parameter has the expected sign but is insignificant. Red indicates that the estimated parameter has the wrong sign and is significant. It was not possible to end up with a final model for gas productivity due to lack of a suitable productivity variable.
Source: Own calculations on Copenhagen Economics, Market Opening Milestones database

In some network industries the market opening indicators faring the best are aggregate indicators as the Market Opening Index itself or one or both latent factors. For example, this is the case in telecom, air transport, postal services and partly in urban transport. In other network industries, most notably electricity, rail transport of any kind, and gas we can statistically pinpoint individual Market Opening Milestones that seem to matter more for successful market opening that other Market Opening Milestones.

For example in electricity, unbundling of the transmission network seems to be a crucial requirement for well functioning market opening. Even though this is not an unrealistic conclusion, we need to stress that extreme care should be exercised when interpreting the role of individual Market Opening Milestones. In most cases milestones are heavily correlated and the existence of penetrating multi-collinearity makes it equally likely that unbundling is just capturing the combined impact of many highly correlated milestones.

In Table 1.2 we list the most significant market opening milestones in electricity, rail freight, telecom and air transport as identified in the final model in each network sector. In addition, we list milestones who are highly correlated (above 80 percent) with the significant milestones.

**Table 1.2: Key drivers, significant market opening milestones in final models with highly correlated other milestones, EU15 member states**

| | Prices | | Productivity | |
|---|---|---|---|---|
| **Sector** | Significant variable | Milestones that are highly correlated with each other | Significant variable | Milestones that are highly correlated with each other |
| Electricity | MOM | Degree of free choice<br>**Unbundling transmission**<br>Third Party Access transm.<br>Third Party Access distrib.<br>Wholesale trading system<br>Congestion management | MOM | Degree of free choice<br>**Unbundling transmission**<br>Third Party Access transm.<br>Third Party Access distrib.<br>Wholesale trading system<br>**Congestion management** |
| Rail (freight) | MOM | Unbundling infrastructure<br>Third Party Access Price<br>**Price control** | MOM | Unbundling rolling stock<br>Privatisation<br>Third Party Access<br>**Degree of free choice**<br>Unbundling infrastructure<br>Third Party Access Price<br>**Price control** |
| Telecom fixed | Factor | **Degree of free choice**<br>**Network unbundling**<br>**Third party access**<br>**Third Party Access Price** | MOI | **All 9 milestones** |
| Air | MOI | **All 12 milestones** | MOI | **All 12 milestones** |

Notes: Market opening milestones in bold makes part of the final model and is according to the general-to-specific methodology the most significant estimators of market opening. Other market opening milestones in normal letter type are milestones highly correlated with the most significant milestones (correlation parameter above 80 percent).

Source: Own calculations on Copenhagen Economics, Market Opening Milestones database

*Additional hypotheses*

We have also tested three supplementary hypotheses concerning the implementation of market opening.

*First*, we investigate the role of changes in the market structure. Two alternative hypotheses prevail. One is that when the market is opened, new entrants enter the market and gain market share, the market structure becomes less concentrated, and the intensifying actual competition drives down prices or drive up productivity, or both. Another hypothesis is that when the market is opened, new entrants are ready to enter the market, but they refrain because the incumbents lower prices and make entry less attractive. In this case, potential entry and the threat of entry is what drive down prices and there is not necessarily any change in market structure.

In some cases we find some evidence that market opening changes the market structure that again changes performance – this is especially the case for mobile telecommunications. On the other hand, we find less evidence of changes in market structure being important for improving performance in electricity and gas. For the remaining sectors, including fixed telecommunications, we find no conclusive evidence of market structure being important or unimportant for improving performance.

*Second,* we ask the question whether there is a difference between formal and effective market opening, the essence being that member states not only need to formally change the market, but they should also set up effective regulatory agencies who are able to guarantee real market opening. The hypothesis is that member states with strong regulatory agencies achieve stronger impacts on performance compared to member states with weaker regulatory agencies.

By and large, we fail to find a link between regulatory strength and performance. This may, however, be a result of a necessarily simplistic incorporation of the variable in the econometric model. An exception is electricity where we have a direct measure of the independence of the regulatory agency. We find evidence that member states with independent electricity regulators have lower prices than countries without independent regulator conditioned on the level of market opening.

*Third*, we look into the possibility that the choice or market opening strategy might influence the impact of market opening on performance. We identify different reform strategies in two dimensions, speed (how fast member states have implemented market opening) and timing (whether member states implemented market opening early or late in the period 1990-2003). In general, we find no evidence of specific reform strategies being crucial for the impact of market opening on sector performance conditional on the level of market opening.

## 1.3. Forecasting the impact of market opening on sectoral performance

We have now established the existence of significant statistical links between market opening and sectoral performance and we have - with due respect to the interpretation of the results - identified the key drivers of the economic impact of market opening.

We now turn to forecasting the impact of market opening on sectoral economic performance, that is we calculate how much prices have gone down and productivity has increased in network industries as a response to the actual market opening that has taken place in each network industry in each member state. The change in prices and productivity are called shocks and are the key input in the simulation model that enables to calculate not only direct impact on sectoral performance, but also the indirect impact on the overall economy due to spill-over effects. I

Forecasting differs from identification. Whereas identification by definition is exclusive – we squeeze out variables that explain less than others – forecasting is inclusive – we hesitate leaving out any information that might be helpful in improving the quality of the forecast. In our context the focus on forecasting introduces two additional considerations that were absent in our search for identification and significance. They require us to modify somewhat our econometric strategy.

*First,* when forecasting we are concerned about achieving the best quantitative estimate of the impact of market opening on sectoral performance. Take prices, in a final model we estimate the relationship between a single market opening milestone and prices and interpret the parameter to the milestone as a measure of how much prices change in percentage terms by a unit change in the market opening milestone. Multiplying the estimated parameter by the actual change in the market opening milestone gives us the shock to sector prices (or productivity) that has been caused by market opening.

However, now the problem of multi-collinearity arises. In reality, we do not know whether the estimated parameter to the market opening milestone included in the final model also captures the impact of a number of other strongly correlated market opening milestones that is not taking into consideration when we calculate price shocks. This induces an error. Instead, we could design a special forecasting model where we enter the complete set of market opening milestones as explanatory variables. We could now calculate the price shock by multiplying a vector of estimated parameters by a vector of actual changes in the market opening milestones included in the estimation.

However, once again the multi-collinearity problem crops up. With multi-collinearity we do not know whether an estimated parameter to a specific market opening milestone in reality also captures the impact of other highly-correlated milestones. But we calculate the total impact of market opening by associating estimated parameters to their own milestones only. This also induces an error.

To solve this problem, we have chosen consistently to estimate forecasting models based on latent factors constructed using factor analysis. Latent factors are statistical aggregates that summarise the maximum amount of information contained in the set of correlated milestones into a limited number, in this case always two, of uncorrelated variables, called latent factors. We have checked the forecasting ability of latent factors relative to the final model for both price and productivity estimations in telecom and electricity. The results confirm our choice of latent factors for forecasting. In a series of simulated out-of-sample estimations latent factors consistently outperforms the milestones included in the final models.

*Second*, we have to adapt the forecasted changes in sectoral performance, the price and productivity shocks, to the properties of the simulation model. A key characteristic of any simulation model of this kind is its benchmark year. The simulation model is constructed such that it always simulates the changes in economic performance relative to its benchmark year, in this case 2001. In this case the benchmark year is determined by the data availability in the most recent version of the GTAP database, version 6 (final). The GTAP database is a de facto global standard for the analysis of trade related policies in simulation models of the same type as the Copenhagen Economics Trade Model.

For this reason we have to split the impact of market opening into two separate contributions. The first contribution should calculate the impact on sectoral performance (or shock) caused by market opening until the benchmark year of the simulation model 2001. This is what we call the short run. Based on the short run shock we can make a backward looking simulation assessing how much of the economic performance in 2001 that has been caused by market opening in network industries. The second contribution should calculate the impact on sectoral performance (or shock) caused by market opening from the benchmark year 2001 into the future. This is what we call the long run. Based on the long run shock we can make a forward looking simulation assessing how much the economic performance will be improved in the future by market opening in network industries (that has already been implemented).

The need to distinguish between short and long run forecast (before and after 2001) requires us to put significantly more structure on the forecasting estimations. We cannot freely choose the best final model but have to choose good model(s) enabling us to make the required distinction between the short and long run. In principle, we can still obtain the split in a static model, but we then must believe in that market opening has immediate impact on economic performance. Intuition and the strong autocorrelation in all data series strongly contradict this belief. Instead we formulate and estimate in some cases proper dynamic models where the short and long run impact can be calculated separately, but directly in the same model. In other cases we use the insight from Pesaran & Smith (1995) and estimate different static panel data models that can be interpreted as representing the short and long run impact.

*Forecasted changes in prices and productivity*
We can now report the forecasted changes in sectoral performance, prices and productivity, as a consequence of market opening. For each network industry we report the forecasted change averaged across a number of different estimation models in order to increase the robustness of the results. And by and large, the results confirm that market opening in the short run has lead to significant reductions in the price of services provided by network industries and to significant increases in network productivity.

Most significantly, prices have been consistently reduced and productivity increased in electricity, air transport, rail freight and telecommunications, cf. Table 4.3. In electricity and air transport prices have gone down and productivity increased by 1-digit percentages. In rail freight and telecommunications market opening has been very significant as prices have gone down by about 20 percent and productivity up by more than 20 percent. In particular, the significant gains in the telecommunication sector and the more modest gains in the electricity sector turn out to be important because these sectors are by far the largest of all network industries and because they services they produce are more extensively used by other industries. These industries are also industries with good data quality.

**Table 1.3: Forecasted changes in sectoral prices and productivity as a consequence of market opening in the short and long run, EU15 member states, 1990-2000**

| | Market opening Factors | Change in market opening Percent | Change in sectoral prices SR | Change in sectoral prices LR min | Change in sectoral prices LR max | Change in sectoral productivity SR | Change in sectoral productivity LR min | Change in sectoral productivity LR max |
|---|---|---|---|---|---|---|---|---|
| Electricity | F1<br>F2 | 24<br>7 | -7,6 | -28 | -60 | 2,3 | 7 | 8 |
| Urban | F1<br>F2 | 32<br>33 | 2,2 | 4 | 6 | 1,0 | 2 | 6 |
| Rail passenger | F1<br>F2 | 68<br>20 | -21,9 | -26 | -27 | -6,6 | -9 | -12 |
| Rail freight | F1<br>F2 | 48<br>59 | -24,9 | -26 | -26 | 46,7 | 83 | 261 |
| Telecom | F1<br>F2 | 46<br>47 | -22,2 | -34 | -35 | 23,8 | 57 | 75 |
| Air | F1<br>F2 | 64<br>48 | -2,3 | -2 | -2 | 13,2 | 15 | 17 |
| Gas | F1<br>F2 | 37<br>50 | -1,0 | -4 | -5 | - | | - |
| Postal services | F1<br>F2 | 16<br>55 | 4,2 | 7 | 8 | 28,1 | 36 | 37 |

Note: Factors are the two latent factors (F1 & F2). Change in market opening is the average percentage change in factors. Change in sectoral prices (productivity) SR is the forecasted price (productivity) change *in 2001* caused by past accumulated market opening. Change in sectoral prices (productivity) LR is the *total* forecasted price (productivity) change caused by past accumulated market opening. Green indicates that the forecast has the expected sign. Red indicates that forecast has the expected sign.
Source: Calculations Copenhagen Economics

In urban transport, rail passenger, gas and postal services the immediate gains of market opening are not as clear-cut. In urban transport and postal services productivity seems to have improved, in postal services quite considerably, but sectoral prices seem to have increased by 2-4 percent. In rail passenger and gas, the opposite is true. Prices seem to have gone down, in particular in rail passenger, but productivity seems to have gone down in rail passenger and unchanged in gas production. However, these industries are also industries with poor data quality.

The short run forecasts of changes in price and productivity are very robust in the sense that different models produce rather similar results. This holds in particular for electricity, telecommunications and rail freight transport. However, the long run forecasts are much less robust in the sense that different models produce rather different results. For this reason we prefer to treat the long run forecasts as indicative only and they should be interpreted with caution.

The instability of the long run forecasts is primarily due to extrapolation. Extrapolation arises when we forecast *outside* the time period for which we estimated the link between market opening and economic performance. For example, the last year included in the econometric models is normally 2000/2001. However, in some cases, in particular telecommunications and electricity, market opening increases dramatically in the years after 2000/2001 giving rise to very large long run forecasts as the forecast assumes the same relationship between market opening and performance before and after 2000/2001. But the dramatic increase in market opening is not reflected in the econometric model. Had it been so, the estimated long-run impact from market opening might very well have been smaller.

Other studies have tried to assess the potential of market opening in (some) network industries. These studies also found a significant link between market opening and prices fairly close to the results in this study. In particular, Doove et al (2001) summarise, compare and extend a number of similar studies and find a statistically significant link between market opening and prices for the following sectors: Air passenger transport, telecommunications and electricity. Using a cross-country regression Doove et al (2001) estimate a price reduction of 31 percent in telecommunication if the 1997-level of barriers *hypothetically* was completely removed and the markets fully opened.[3] In electricity prices would go down by 11 percent in a similar hypothetical exercise.

Transforming these figures to account for the *actual* reduction in market opening over the period 1997-2001, the results from Doove et al (2001) can be translated into a decline in telecommunication prices at 14 percent and electricity prices at 5 percent. In comparison, this study suggests a reduction of 22% and 8% over the period 1990-2001 for telecommunications and electricity, respectively. Considering the difference in time periods the estimated impacts seem to be very similar.

## 1.4. Simulating the overall economic impact of market opening

We have now measured the exact path of market opening for all seven network industries in all EU15 member states and we forecasted the actual shock, short run and long run, to prices and productivity in each network industry as a consequence of market opening. We now turn to the next step: How to incorporate the forecasted price and productivity shocks into a suitable simulation model.

We use the Copenhagen Economics Trade Model to calculate the economy-wide impact of market opening in the network industries. The Copenhagen Economics Trade Model (CETM) is a global, multi-regional general equilibrium model. The model represents state-of-the-art developments within models of services production and it has been specifically designed for the analysis of market opening in European network industries. To understand how the effects of market opening can be simulated in a CGE model, it is useful to review some basic concepts relating to these types of models.

A CGE model is a mathematical model of an economy. The model is calibrated to a benchmark year representing equilibrium. This initial state of the model is referred to as the benchmark scenario. The purpose of the benchmark scenario is to provide a basis for comparison with different alternative scenarios. In our case, the CETM -model draws on the GTAP database (version 6) which provides internally consistent data on production, consumption and international trade by country and sector for the global economy in 2001. That is, the benchmark year of the CETM-model is 2001.

To analyse the effects of a policy instrument as market opening, it is necessary to define a hypothetical situation that represents the effects of implementing that measure. For example, a policy instrument could increase productivity in a certain sector. This is called a counterfactual policy scenario, since the scenario deviates from the de facto situation as represented in the benchmark scenario. The counterfactual policy scenario is subsequently simulated in the model and compared to the benchmark scenario to determine the economic outcomes.

*Ex ante and ex post evaluations*

In our case, we aim to construct two different counterfactual policy scenarios. First, we want to measure the economic impact of past market opening that has already been made part of the

3 Doove et al (2001) perform the analysis on the basis of 24 OECD countries. However, all figures are given for the 12 EU member states included in their analysis.

economy in the benchmark year 2001. This is the short run impact. Second, we want to measure the economic impact of past market opening that has not yet made part of the economy in the benchmark year 2001. This is the long run impact. The first scenario is a so-called *ex post* or *backward looking* scenario. The second scenario is a so-called *ex ante* or *forward looking* scenarios.

CGE models are traditionally used for *forward looking evaluations* of policy proposals to facilitate an informed choice between different options. The procedure is straightforward. For the ex ante evaluation we calculate the price and productivity (long run) shock that has been caused by historical market opening but which has not yet been converted into economic outcomes in the benchmark year 2001. Then we subsequently run the simulation model. The difference between the economic outcome in the counterfactual and benchmark scenarios are interpreted as the consequences of market opening.

However, CGE models can also be used for *backward-looking evaluations* of the effects of policies already implemented, but the procedure is not equally straightforward. The analytical challenge is to calculate how much worse off the EU economy would have been in 2001, had market opening not taken place. Accordingly, the counterfactual policy scenario represents the hypothetical situation that market opening had not taken place. Since the policy change involves market opening, eliminating market opening corresponds to market closing. This is performed by introducing negative price and productivity (short run) shocks that “take out” the impact of market opening on sectoral performance.[4]

For the ex post evaluation we calculate the price and productivity shock that would have been caused by historical market opening and that according to the dynamic specification has already been converted into economic outcomes in the benchmark year 2001. Then, we run the simulation model with negative shocks essentially raising prices and reducing productivity such that the impact of market opening is nullified. Again, the difference between the economic outcome in the benchmark and counterfactual scenarios are interpreted as the consequences of market opening.

*Overall assessment*

The model analysis demonstrates that market opening in the network industries has contributed significantly to the economic performance of the EU15 economy[5]. The simulations show that the accumulated price and productivity effects accruing from market opening until 2001 (the short run) result in a 1.9 percent increase in welfare in EU15, cf. Table 1.4. This corresponds to an annual gain of approximately €98 billion in monetary terms. Furthermore, the effect on the labour market corresponds to a net addition of approximately 500 000 new jobs across the EU15, both inside and outside the network industries.

4 The simulation strategy is conceptually identical to the methodology used by the European Commission for the ex-post evaluation of the Single Market Program (Capros et al, 1996).

5 The model incorporates the 10 new member states together with the rest of the world. Including them individually will not markedly impact the EU15 member states, and market opening in the EU15 will, likewise, not markedly impact the new member states. Only market opening within the new member states will have a significant economic impact. However, since market opening has not been analysed in the new member states, no market opening milestones (MOM) or market opening index (MOI) exist. Consequently, it is not feasible to calculate the economy wide effects of market opening in the new member states.

**Table 1.4: Economy-wide effects of market opening for the EU15**

| | Effects accruing from market opening 1990-2001 (short-run effects) | |
|---|---|---|
| | % change | Absolute effect |
| Welfare | 1.9 | € 98 bn |
| Value added | 2.0 | € 150 bn |
| Employment | 0.3 | 500 000 jobs |

Note: The table shows the economy-wide effects that emerge when the economy has adjusted fully to the effects of market opening. Welfare is measured as comprehensive consumption.
Source: CETM model - Copenhagen Economics.

The gains of market opening arise because market opening induces competition and more efficient production in network industries giving rise to lower prices on (most) network services and greater choice. Lower prices reduce the costs of all industries using network services and stimulate overall demand. The boost in demand creates new jobs.

The overall gains are for several reasons primarily associated with market opening in telecommunication and electricity. *First*, these two sectors account for almost two thirds of all output from the seven network industries covered by this study. *Second*, market opening has been faster and more penetrating here than in all other network industries. *Third*, the impact of market opening on price and productivity is by themselves larger and more significant than in other network industries

In other network industries, in particular rail freight transport and air (passenger) transport, market opening has also managed to increase productivity and reduce prices, but the overall economic impact is less comprehensive as both sectors are small compared to electricity and telecommunications.

In the remaining network industries, rail passenger transport, urban (passenger) transport, postal services and gas, it has been difficult to identify unambiguous and credible links between market opening and economic performance. There may be several reasons for this outcome. *First*, there might be no link and market opening has not and will not give rise to better economic performance in these sectors. *Second*, there might be a positive link but market opening has not yet been sufficiently comprehensive to induce the associated economic gains. *Third*, there might be a positive link but the poor data quality prevents us from identifying the link. However, as data quality in these network industries is consistently inferior to data quality in the other industries, we tend to emphasize the third explanation.

All EU15 member states have gained from market opening in network industries but with significant differences. Some member states as Sweden and Finland have gained noteworthy increases in welfare above 5 percent, while other member states as Greece has hardly gained anything, cf. Table 1.5 and Figure 1.1. Detailed results at the Member State level are presented in Appendix A. When interpreting the results, it is important to note that market opening has actually already taken place and that many effects have already emerged (the analysis is essentially an ex-post assessment)[6].

The differences between member states are primarily rooted in differences in the degree and depth of market opening in telecommunications and electricity. Those member states who

[6] The effects are therefore calculated as changes compared to what the EU economy would look like without market opening. For example, when the effects of market opening are fully realised, there will be 500 000 more jobs in the EU economy than if market opening had not taken place (though many of these new jobs have already been created).

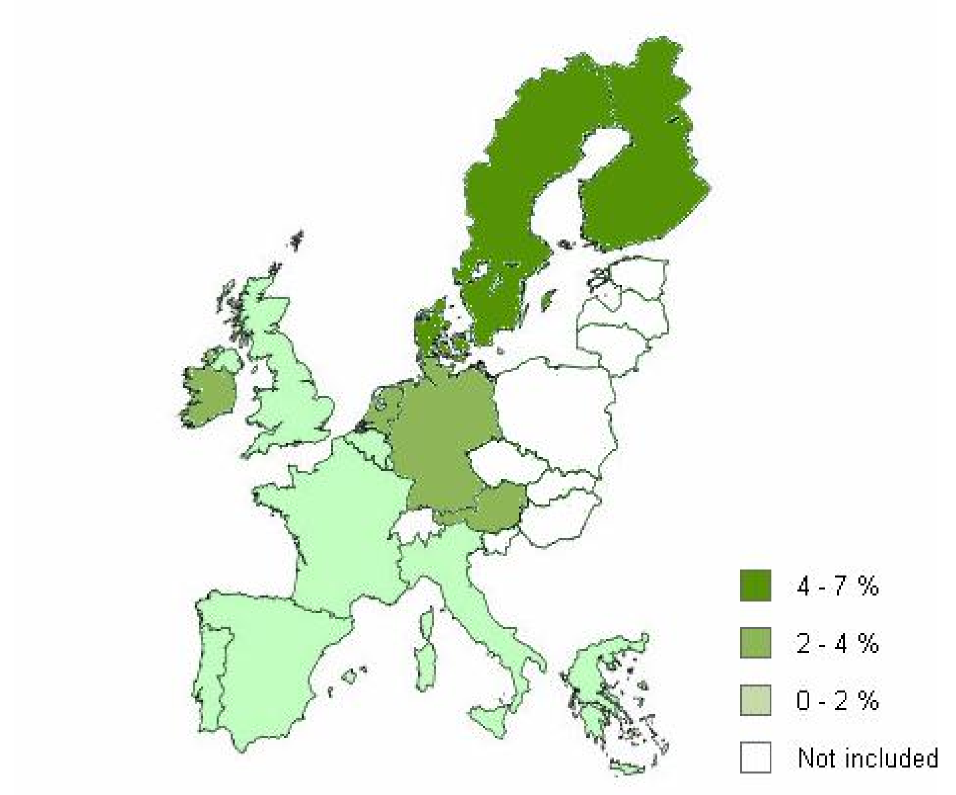
opened markets *more* and who started *early* have gained the most. The latter is due to the fact that it takes some time for market opening to fully have an impact on prices and productivity.

**Table 1.5: Distribution of welfare effects across member states**

| | Welfare | | Benchmark value added | Market Opening Index (MOI) | |
|---|---|---|---|---|---|
| | | | | Point change 1990-2000 | |
| **Member State** | % change | Absolute effect | 2001 | Telecom | Electricity |
| **EU15** | **1.9** | **€ 98 bn** | **€ 7690 bn** | **47** | **25** |
| Austria | 2.3 | € 3 bn | € 177 bn | 55 | 00 |
| Belgium and Luxembourg | 1.5 | € 3 bn | € 247 bn | 49 | 22 |
| Denmark | 4.9 | € 4 bn | € 153 bn | 85 | 45 |
| Finland | 6.5 | € 4 bn | € 115 bn | 50 | 66 |
| France | 1.4 | € 10 bn | € 1241 bn | 39 | 15 |
| Germany | 2.2 | € 26 bn | € 1776 bn | 58 | 40 |
| Greece | 0.4 | € 0 bn | € 122 bn | 16 | 00 |
| Ireland | 2.2 | € 1 bn | € 104 bn | 37 | 16 |
| Italy | 1.4 | € 10 bn | € 1048 bn | 62 | 02 |
| Netherlands | 3.3 | € 7 bn | € 357 bn | 69 | 20 |
| Portugal | 1.6 | € 1 bn | € 105 bn | 47 | 06 |
| Spain | 1.4 | € 6 bn | € 597 bn | 43 | 14 |
| Sweden | 5.9 | € 7 bn | € 204 bn | 49 | 63 |
| United Kingdom | 1.4 | € 17 bn | € 1443 bn | 30 | 29 |

Note: Welfare is measured as comprehensive consumption. The change in the Market Opening Index from 1990 to 2000 is presented because it affects prices and productivity in the network industries until 2001.
Source: CETM model – Copenhagen Economics, Copenhagen Economics (2004) and GTAP6 database.

**Figure 1.3: Distribution of (short run) welfare gains of market opening between EU15 member states**




Most of the employment gains are created in service sectors. Clearly, more jobs are created in service because service sectors constitute the major part of the economy. However, this is not the only reason. Service sectors also gain more jobs because they are the most intensive users of output from many network industries. This is in particular true for telecommunications and postal services and still true, but less so, for all transport sectors. It means that input costs shrink more for service sectors than for other sectors which can be converted into a relative cost advantage when overall demand increases.

The economic stimulus provided by market opening increases economic activity across the EU. This contributes to increased economic welfare, but at an environmental cost. The increased activity in the EU economy implies higher $CO_2$ emissions due to higher use of energy and fossil fuels. In total the calculations show that total $CO_2$ emissions in the EU15 increase by approximately 4 percent for the EU15 as a result of market opening. In absolute terms, the higher emission levels are concentrated to the electricity sector and petroleum and chemical industries.

In the future, we will most likely see further gains in welfare and employment stemming from market opening in network industries that has already been implemented before the turn of the century. The reason is that there is a time lag between implementation of market opening and its economic impact. These longer term gains may double the impact on welfare and employment from market opening in network industries, but we shall strongly emphasise that the longer term gains are considerably more uncertain than the gains already achieved and reported above. The large uncertainty regarding the long-run effects means that no reliable conclusions can be drawn regarding the economy-wide effects of market opening.

# Chapter 2 Measuring market opening in EU15 network industries

Market opening implies the implementation of complex, qualitative policies in a large number of dimensions. In order to measure market opening properly we need to develop a methodology that enables us to transform qualitative information about specific policies into quantitative information in a meaningful, transparent and - as far as possible - unambiguous way. In addition, our methodology must be able to retain the multi-dimensional character of the issues we analyse, but it should also incorporate tools allowing us to organise and simplify the multi-dimensionality problem in order to improve analytical tractability, econometric feasibility and enable horizontal analyses.

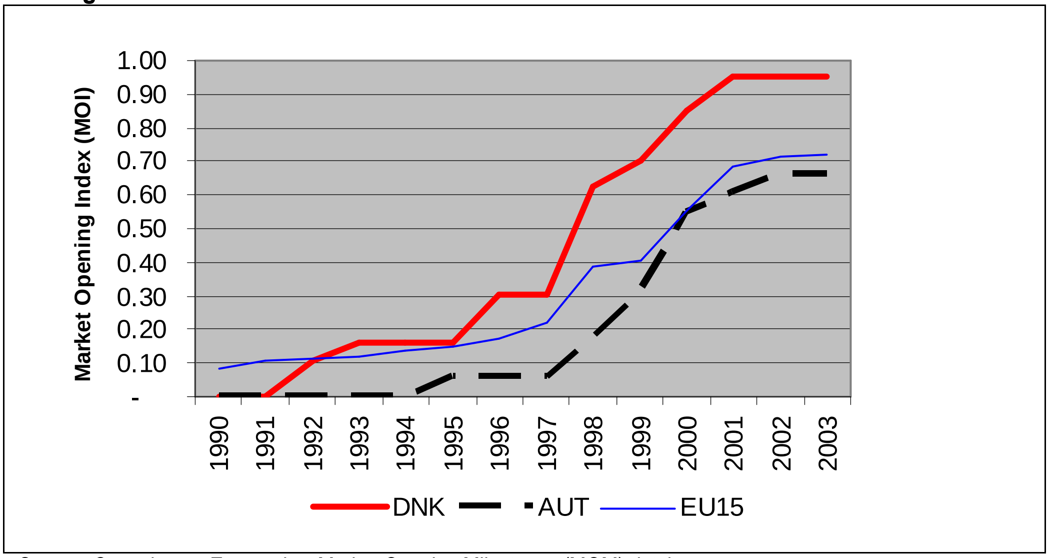
## 2.1. The Market Opening Index

We have chosen to design an indicator measuring the extent of market opening in a network sector. We call this indicator the Market Opening Index (MOI). The Market Opening Index is an aggregate indicator that for a given year and sector and on a scale between zero and unity summarises the extent of market opening relative to a state of full market opening. The index is constructed such that full market opening, unity value, is unlikely to be achieved by any member state.

The Market Opening Index is based on *Market Opening Milestones*. Member states achieve market opening over time by implementing an increasing number of *Market Opening Milestones*. A Market Opening Milestone is a concrete and specific policy initiative under government control. In each sector we define full market opening as the implementation of a complete set of sector specific Market Opening Milestones. When all these milestones are implemented, no further policy initiatives can – in principle – lead to more market opening. When one of these policies is implemented by a member state, we say that the member state has passed a Market Opening Milestone and the value of the Market Opening Index increases in the year of implementation and in all succeeding years.

In this way, the Market Opening Index describes for each member state the time path of market opening in a given network sector. Figure 2.1 illustrates the idea using market opening in telecommunications as an example. Denmark is a member state where market opening in most years progresses faster than EU15 on average. Austria is an example of the opposite.

**Figure 2.1: Market Opening Index for telecommunications in Denmark, Austria and average EU15**

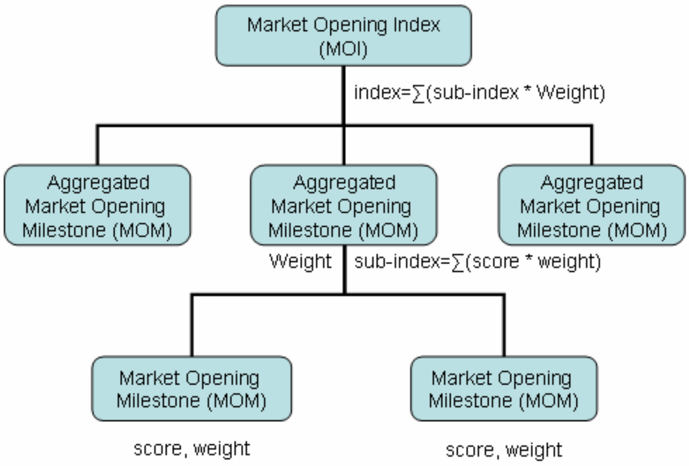



Source: Copenhagen Economics, Market Opening Milestones (MOM) database

The value of the Market Opening Index in a given year is calculated as the weighted sum of the scores for all Market Opening Milestones. The calculation takes place on two levels, a lower level and an upper level.

On the lower level, each Market Opening Milestone is given a *score*. A Market Opening Milestone has a zero score, if the milestone yet has to be implemented by a member state or a positive score between zero and unity if it has already been implemented. The score is based on expert estimates of the importance of the milestone for market opening. In addition, a Market Opening Milestone is given a (positive) weight indicating the guesstimated relative importance within a sub-category of related milestones. It is now possible to calculate an aggregated Market Opening Milestone for any given sub-category of Market Opening Milestones by summing the weighted scores of milestones within that sub-category, cf. figure 2.2. We have between five and twelve Market Opening Milestone for each Market Opening Index.

**Figure 2.2: The hierarchy of the Market Opening Index**



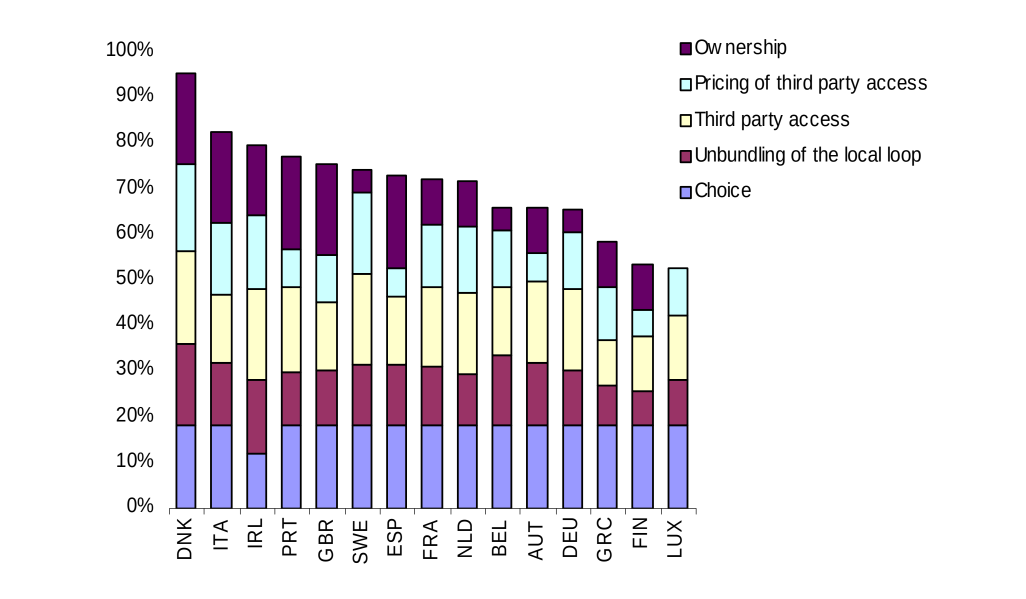

Source: Copenhagen Economics.

On the upper level, each aggregated Market Opening Milestone inherits a score from the lower level and is now given a weight. The weights reflect the guesstimated relative importance of the sub-category relative to other sub-categories. It is now possible to calculate the Market Opening Index by summing the weighted scores of the aggregated Market Opening Milestone.

As an example, we show in figure 2.3 how the Market Opening Index in 2003 for telecommunications is based on five different aggregated Market Opening Milestones, each representing a sub-category of related Market Opening Milestones covering Ownership (of networks), Third Part Access, Pricing of Third Part Access, Unbundling of the local loop and the extent of free customer Choice.

The example from telecommunications shows that in most member states consumers have a large degree of free choice but that accompanying policies such as pricing of third party access, unbundling of the local loop and degree of private ownership account for the different levels of market opening in member states.

**Figure 2.3: The structure of the Market Opening Index in telecommunications, EU15 member states, 2003**



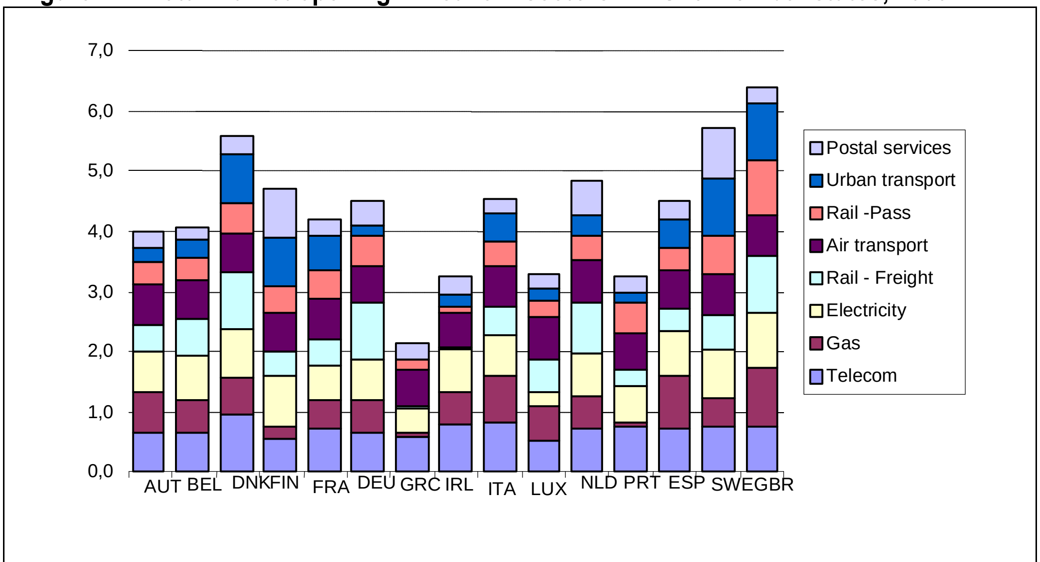

Source: Copenhagen Economics Market Opening Milestones Database

## 2.2. Market opening in EU15 network industries

We have developed and constructed Market Opening Indices for seven network sectors for EU15 member states for each year in the period 1990-2003. The indices are based on a detailed reading of national and EU legislation and a vast number of national and international academic and policy studies. In this section, we provide a general overview of the state of market opening in the seven network sectors in the EU15 member states.

In aggregate, there is considerable variation in the degree of market opening between member states, cf. figure 2.4. Some member states have consistently opened their markets, e.g. the United Kingdom and the Nordic countries. Other member states, e.g. Greece, Ireland, Portugal and Luxemburg have been much more hesitant to open markets.

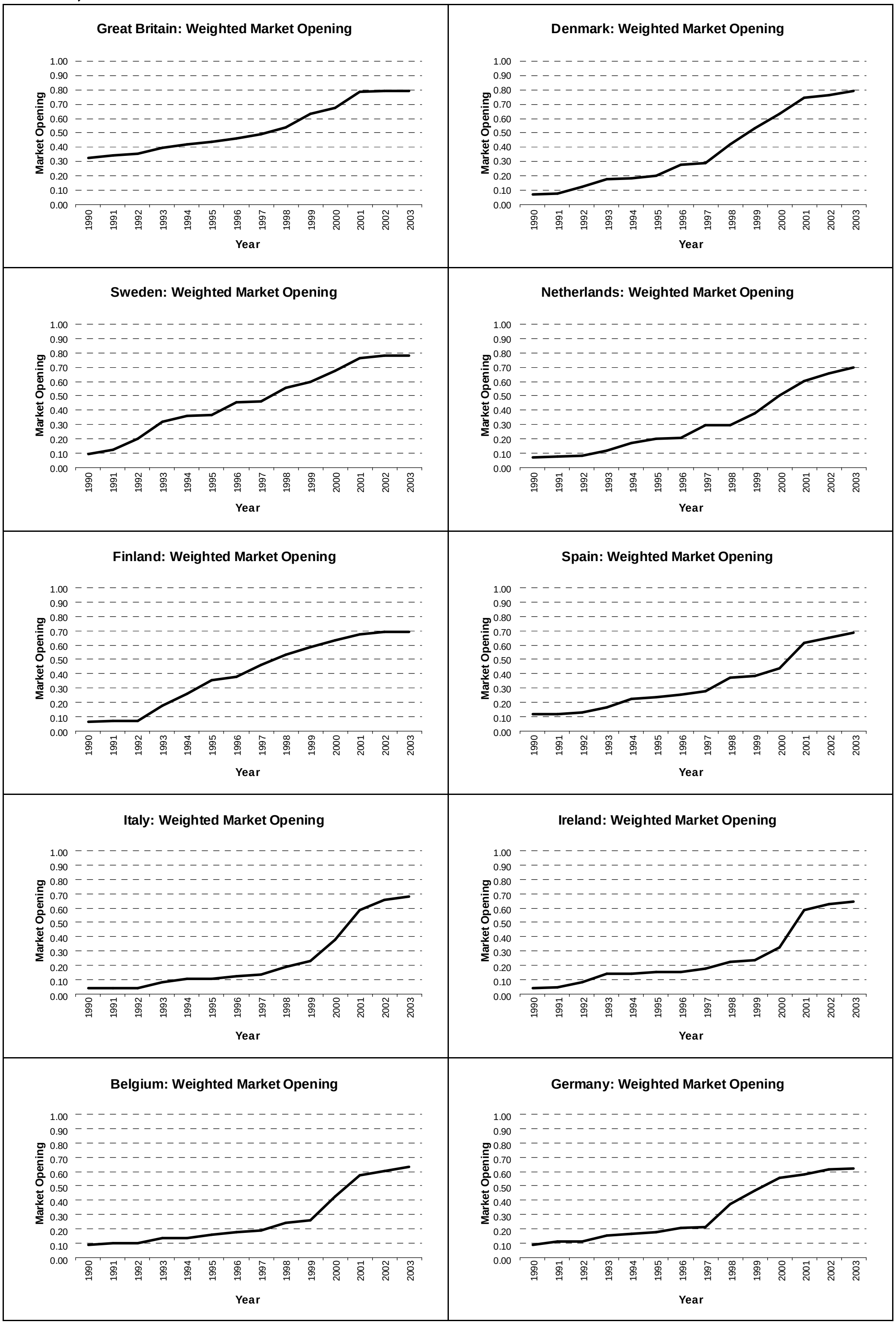
**Figure 2.4: Total market opening in network sectors in EU15 member states, 2003**

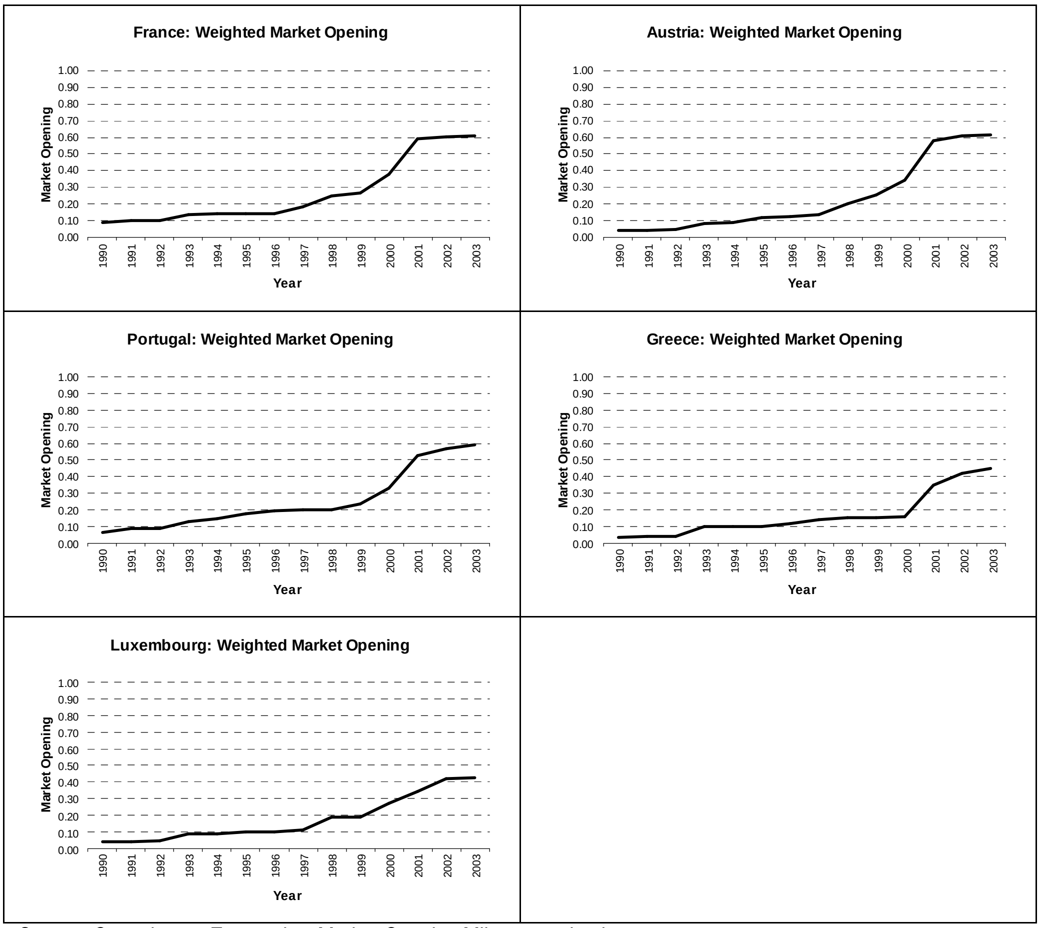



Note: An index value of zero signifies a complete absence of market opening in all industries. A value of seven signifies that market opening is complete in all network industries.
Source: Copenhagen Economics, Market Opening Milestones database

The path of market opening also differs significantly between member states, cf. Figure 2.5, with all countries except the UK starting from a fairly low level and then choosing different speed and timing of market opening policies.

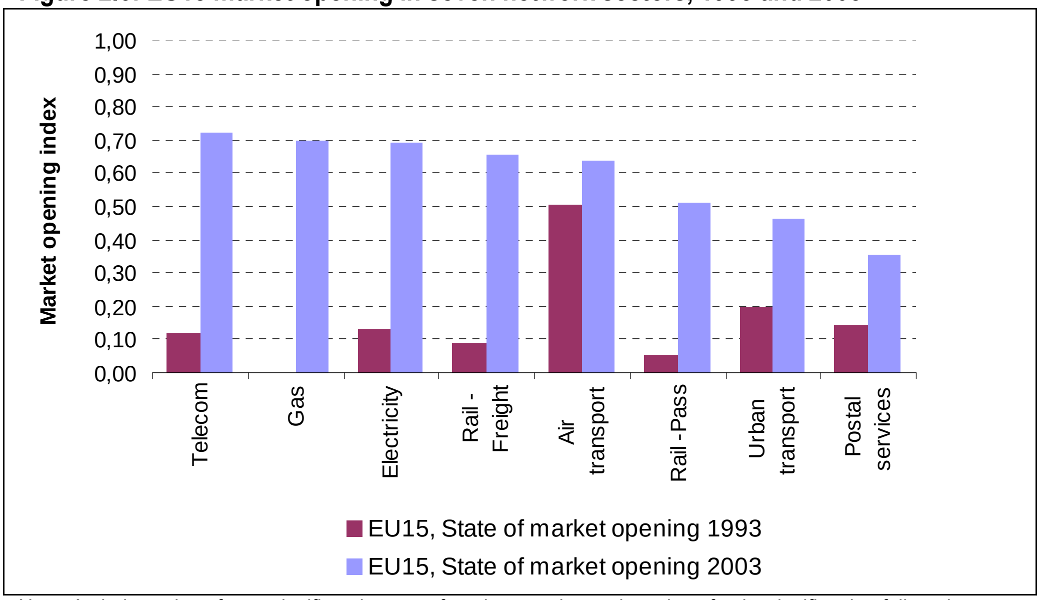
**Figure 2.5: The average path of market opening in network industries, EU15 member states, 1990-2003**






Source: Copenhagen Economics, Market Opening Milestones database

**Figure 2.6: EU15 market opening in seven network sectors, 1993 and 2003**




Note: An index value of zero signifies absence of market opening and a value of unity signifies that full market opening has been achieved. Therefore, the higher the value of the index is, the more market opening has taken place. The EU-wide Market Opening Index is a weighted average, constructed by using the indices of the individual countries weighted by consumption shares of the output in each sector. For example Italy generates 10 percent of the total electricity in EU15 and therefore, the Italian Market Opening Index for electricity has a 10 percent weight in the overall EU15 index for electricity. Similar types of weights are used in the other sectors.
Source*:* Copenhagen Economics, Market Opening Milestones (MOM) database.

The degree of market opening differs significantly between sectors, not only in 2003 but also in the beginning of the period in 1990, cf. figure 2.6. Some sectors had relatively open markets already in 1993, but then markets stopped to grow more open. This is the case for e.g. urban transport and postal services. Other sectors had limited market opening in 1993, but then market opening moved forward swiftly and these sectors today have the most open markets. This is the case for e.g. telecom, gas, electricity and rail freight.

Air transport stands out as the only sector where almost all the current degree of market opening had been achieved before 1993. Air transport also stands out as a sector where market opening seems to have been tightly coordinated between member states. The time path of market opening in air transport is almost identical for all member states.

# Chapter 3 Identifying significant links between market opening and sectoral performance

This chapter provides an overview of the empirical analysis of the link between market opening and sector performance. The main objective is – if possible - to identify statistically significant links between key market opening policies in order to conclude whether market opening has impacted on sectoral performance (significance) and if affirmative what specific policies have contributed the most to economic performance (identification).

We set up econometric models explaining changes in the dependent variable, sector performance, as a function of market opening taking into due consideration the impact of other explanatory variables. The most important output of the econometric analysis is statistically significant and economically meaningful parameters telling us how sector performance changes when certain market opening policies are implemented. Since we have information on market opening across time and member states, the natural set-up is an econometric panel data model.

The regression results demonstrate clear evidence of a statistically significant link between market opening and sector performance, in particular prices and productivity. Importantly, the estimated parameters have the expected sign in most cases, such that market opening leads to *lower* prices and *higher* productivity. This is in particular true in electricity, telecommunications, air transport and rail freight transport. In sectors with poor data quality like urban transport, rail passenger and postal services we sometimes fail to establish significance or meaningful parameters.

The regression results are able to identify market opening policies (milestones) that contribute more to economic performance than others. This is done by gradually excluding insignificant variables until we reach a preferred simple and parsimonious model with sole significant variables. These market opening policies can – from a statistical point of view – be viewed as important determinants of sector performance.

In some cases the variable representing market opening is an aggregate index as for example the Market Opening Index. In these cases we can conclude that no single market opening policy can explain performance as market opening policies complement each other and should be viewed as a package. In other cases we are left with a single or two market opening policies as the sole significant variables. In these cases, however, we cannot conclude that these policies are *the only relevant* market opening policies. We have to acknowledge that other market opening policies may play an important role because many Market Opening Milestones are heavily correlated with each other so that any exercise to isolate partial impacts must be subject to due reservation.

In addition to the objectives stated above, we will seek information about a range of related questions that may cast a more detailed light on the relationship between market opening and sector performance.

We have tried to find out through which channels market opening policies influence economic performance. Does market opening lead to actual entry of new firms improving competition and sectoral performance or is potential entry that is the threat of entry sufficient? To choose between the two hypotheses, we estimate an auxiliary equation with market structure as the dependent variable and market opening and other variables as explanatory variables.

In some cases we find some evidence that market opening changes the market structure that again changes performance – this is especially the case for mobile telecommunications. On the other hand, we find less evidence of changes in market structure being important for improving performance in electricity and gas. For the remaining sectors, including fixed telecommunications, we find no conclusive evidence of market structure being important or unimportant for improving performance.

Moreover, we ask the question whether there is a difference between formal and effective market opening, the essence being that member states not only need to formally change the market, but they should also set up effective regulatory agencies who are able to guarantee real market opening. The hypothesis is that member states with strong regulatory agencies achieve stronger impacts on performance compared to member states with weaker regulatory agencies.

By and large, we fail to find a link between regulatory strength and performance. This may, however, be a result of a necessarily simplistic incorporation of the variable in the econometric model. An exception is electricity where we have a direct measure of the independence of the regulatory agency. We find evidence that member states with independent electricity regulators have lower prices than countries without independent regulator conditioned on the level of market opening.

Finally, we look into the possibility that the choice or market opening strategy might influence the impact of market opening on performance. We identify different reform strategies in two dimensions, speed (how fast member states have implemented market opening) and timing (whether member states implemented market opening early or late in the period 1990-2003). In general, we find no evidence of specific reform strategies being crucial for the impact of market opening on sector performance conditional on the level of market opening.

The chapter proceeds as follows: Section 3.1 provides an overview of the questions we seek to answer in the sectoral analyses, section 3.2 gives a detailed description of the econometric strategy and section 3.3 summarises the results from the sectoral analyses. The sectoral analyses are presented in Part II, chapters 6-12.

## 3.1. The basic econometric choices

In this section we formally set up estimation equations for price and productivity. There is a long tradition of estimating these variables, we can design the estimation equations on sound theoretical basis and we can rely on a multitude of related studies. We now explain how to design performance equations to be estimated for price and productivity.

The design of the performance equations should make it possible to explain as much variance as possible in the performance variables. Our analysis of the relationship between market opening and productivity or price has to begin with a simple model providing a sound theoretical basis for expanding the model with more explanatory variables, including variables representing market opening.

First, we decide how to model production in networks sectors. Second, we decide how market opening should enter into the regressions.

*Price and production equations*

We base our estimations on a Cobb-Douglas productivity model, where production value is produced using capital and labour. It is a simple and well-known model for describing production cf. Equation 3.1:

*Equation 3.1* $$Y = AK^{\gamma_K^v} L^{\gamma_L^v}$$

*Y* is production value, *A* exogenous technological changes, *K* the value of capital input and *L* the value of labour input. $\gamma_K^v$ and $\gamma_L^v$ are the capital and labour shares in value added. We refer to Equation 3.1 as the *productivity equation*. Taking the natural logarithm (*ln*) of this equation results in a linear equation directly suitable for estimation:

*Equation 3.2* $$\ln(Y) = \gamma_K^v \ln(K) + \gamma_L^v \ln(L) + \ln(A)$$

From Equation 3.1 we see that technological change, *A*, is everything not captured by capital and labour, which would be the error term in an estimation equation. This error term is famously known as the *Solow residual*. When we include other variables to explain value added (*Y*), e.g. market opening policies, we are in reality trying to explain how much market opening can contribute to explaining the Solow residual.

We now turn to the price equation. Following the line of thought in the previous section and in Jorgenson (1986) we start with an equation where the price of a single output unit from a network industry is a function of the input prices:

*Equation 3.3* $$\ln(P) = \gamma_K^{p1} \ln(P^K) + \gamma_L^{p1} \ln(P^L) + \eta$$

$P^K$ is the user cost of capital, $P^L$ the wage, and $\eta$ is a stochastic error term. We expand this price equation to include the effect of increased productivity from e.g. market opening meaning that the same amount of output can be produced using less input. We estimate the price of output as a function of the price of the inputs multiplied by the unit amounts of inputs:

*Equation 3.4* $$\ln(P) = \gamma_K^p \ln\left(P^K \frac{K}{Y}\right) + \gamma_L^p \ln\left(P^L \frac{L}{Y}\right) + \eta$$

*Market opening and other explanatory variables*

We need to augment the price equations with a number of other explanatory variables. Therefore, in reality we estimate production value (*Y*) using Equation 3.5 and price (*P*) using Equation 3.6:

*Equation 3.5*

$$\ln Y = \gamma_K^y \ln K + \gamma_L^y \ln L + Z^y \gamma_z^y + M\beta_M^y + MOI\beta_{moi1}^y + f(MOI)\beta_{moi2}^y + \eta^y$$

*Equation 3.6*

$$\ln P = \gamma_K^p \ln\left(P^K \frac{K}{Y}\right) + \gamma_L^p \ln\left(P^L \frac{L}{Y}\right) + Z^p \gamma_z^p + M\beta_M^p + MOI\beta_{moi1}^p + f(MOI)\beta_{moi2}^p + \eta^p$$

The $\gamma$'s and $\beta$'s are (vectors of) parameters to be estimated. *Z* is a vector of control variables. These are variables that describe time-varying differences between member states that could help explain the variation in productivity and prices. *M* is a vector of variables that measure market structure (se below). Examples of market structure indicators are market share of the incumbent or percentage of consumers switching supplier.

Finally, *MOI* measures the level of market opening. The MOI indicators can either be the Market Opening Index itself, the Market Opening Milestones or the factors determined in the factor analysis. Notice how a function *f* of *MOIs* enters the equation. The reason is that we also wish to include interactions between the *MOIs* as well as squared terms. That may allow us to investigate whether various market opening policies reinforce each other or whether the impact of market opening is level dependent.

The issue of including lags in the estimation equations is not addressed here and Equation 3.5 and Equation 3.6 are shown without time (and member state) indices. In the actual estimations we have observations over several time periods.

We base our choice of control variables on a selective reading of similar empirical analyses in the existing literature. Many different control variables have been used. However, it seems the control variables fall within the same five categories regardless of whether the dependent variable is productivity or price, cf. Table 3.1. The five categories measure the economic structure and the technological maturity of the market, penetration in the population, infrastructure issues, and income levels.

**Table 3.1. Selected control variables used in similar studies**

| Sectors | Categories of control variables | | | | |
|---|---|---|---|---|---|
| | Economic structure | Technological maturity | Population penetration | Infra-structure | Income and growth |
| Telecom | Price rebalancing indicator | Share of digital subscribers | Revenue per capita | - | GDP per capita |
| Electricity | - | Share of generation technologies | - | Urbanisation | GDP per capita |
| Railway | - | - | - | - | - |
| Air transport | - | Share of direct and round trip tickets | Passenger share in population | - | Purchasing power |

Source: Appendix A.

We have considered other functional forms than the Cobb-Douglas model, such as the CES model (Constant Elasticity of Substitution) and the translog[7] model (Transcendental Logarithmic). Both models are more flexible than the Cobb-Douglas model, in particular the translog model. The Cobb-Douglas model imposes constant unity elasticities of substitution between all the input factors; the CES-model imposes constant but not unity elasticities of substitution, whereas the translog model allows the elasticity of substitution to vary freely between the input factors.

However, the translog model increases the number of parameters to estimate. To identify the parameters of the flexible translog model more and better data are required than for any other functional form. In this study we typically have less than 150 observations putting strict upper limits on the number of parameters that we are able to estimate. It is even more important that

[7] See Jorgenson (1986) for a discussion of translog models.

the translog model also requires detailed supplementary data in order for us to properly interpret the model and asses the model validity. Such detailed data is mostly either non-existent or not publicly available for most of the seven network industries. For example, in telecommunications we do not have the exact sectoral user cost of capital, but only the real interest rate. This fact seriously undermines the practical possibilities for using the translog model *in the current context*.

Overall, we conclude that the downside of a more flexible functional form clearly outweighs the benefit. In particular, in a context where we also estimate dynamic models and allow for simultaneity. Both properties dramatically increase the number of parameters to estimate and places further demands on the quantity and quality of data.

*The choice of market opening variable*
We also have to choose how to represent market opening. The Market Opening Index is a convenient tool for capturing the aggregate progress of market opening for illustrative purposes, but for the two objectives of this study the information contained in the aggregate Market Opening Index may be too limited: When searching for significance and key drivers of market opening, we need to be able to sort out the impact of individual Market Opening Milestones and cannot necessarily rely on the Market Opening Index only. The Market Opening Index reduces the number of variables in the model but severely restricts the information set, thereby increasing the risk of wrongfully estimating an insignificant parameter to market opening.

Market Opening Milestones, on the other hand, convey a richness of information but is often marred by multi-collinearity since member states often implement different milestones simultaneously. To mitigate the advantages and disadvantages of these two choices we have also applied factor analysis.

Factor analysis is a statistical technique to find the minimum number of *factors* (or latent variables) that explain the maximum amount of the overall covariance of the *observed variables*. The factors are linear combinations of the observed variables and each factor is characterised by a set of parameters, called *factor loadings*, expressing the factor's correlation with the observed variables. The observed variables are then associated with the factor to which they load the most.

In our context, the *observed variables* are the 5-12 Market Opening Milestones depending on the network industry in question. Typically, for each sector we find two *factors* that can explain 70-80 percent of the variation in the Market Opening Milestone. Each Market Opening Milestone is associated to the factor with the highest factor loading.

Factor analysis is appealing because it reduces the number of explanatory variables in the sector performance equations, thereby reducing the problem of multi-collinearity due to highly correlated explanatory variables[8]. At the same time the data based factor analysis ensures that the resulting factors represent a large part of the variance of the Market Opening Milestone. Factor analysis and latent factors are going to play important roles in the study due to the need to control for the pervasive multi-collinearity between Market Opening Milestones.

There are also downsides to factor analysis. The method is sensitive to modifications in data. Data revisions, possibly implying additional observations (such as the inclusion of new countries), may change the set of weights that are used to compute the resulting factors. The results are also likely to be sensitive to the presence of outliers, which may introduce a spurious variability in the data. Finally, data limitations may make statistical identification and

[8] In the case of multi-collinearity it is difficult to evaluate the significance of each of the explanatory variables.

economic interpretation difficult. Se Appendix A for more detailed information about factor analysis and chapters 6-13 for the estimation of relevant factors in each network industry.

Thus, in the econometric analysis market opening can, depending on the circumstances, be represented by the Market Opening Milestones, Market Opening Index or latent factors constructed by factor analysis.

*Transmission mechanisms*
When market opening occurs, it might increase the number of competitors on the market, stimulating competition and in turn improving performance. Or market opening might increase competition and raise performance directly without necessarily increasing the number of competitors on the market. The question is whether actual entry or potential entry is required for market opening to work.

The theory of contestable markets focuses not on the number of firms competing *in* a market rather on what is stopping firms from successfully competing (contesting) *for* the market. The reason is that if nothing prevents firms from entering a monopoly market and competing on equal footage with the incumbent, there is no reason why that market should not function just as well as a market with many suppliers. So a contestable market should function just as well with one supplier as with many. That of course directs focus on what might prevent free entry (and exit) from a market – that is barriers to entry.

We measure barriers by our Market Opening Milestones, and regress market structure on market opening and other explanatory variables, cf. Equation 3.7.

*Equation 3.7* $$M_{it} = MO_{it}\tilde{\beta} + Z_{it}^{m}\phi + \tilde{\alpha}_i + \tilde{\varepsilon}_{it}$$

$M_{it}$ is a measure of market structure, $MO_{it}$ is a measure of market opening which in the actual estimation will be represented by the latent factors, $Z_{it}^{m}$ is a matrix of control variables and $\phi$ is the corresponding parameter vector. Comparing the market structure estimation with the performance estimation we hope to gain insight into the channels through which market opening works. Since we expect market structure to affect performance, indicators reflecting market structure should be included in the performance equations as we proposed in Equation 3.5 and Equation 3.6.

## 3.2. Step-by-step estimation strategy

The purpose of this subsection is to outline our estimation strategy when looking for a significant link between some key market opening policies and economic performance. We present a check list describing how we conduct the estimations step by step. Many of the underlying econometric concepts are further described in Appendix A.

*Factor analysis*
First, we apply factor analysis to extract a limited number of factors from the complete set of Market Opening Milestones. We use the so-called Principal Component-factor approach (PCF) to find the number of factors to extract and if the assumptions behind PCF-approach are accepted we also estimate factors using PCF. If not, we use the Principal Factor (PF) approach. We calculate the factor scores used to make the factors from the observable variables using the intuitive method used by OECD (see Boylaud and Nicoletti (2000)).

*Performance estimations*
We start out by trying so sort out whether static or dynamic panel data models are the better representation of data using different models and estimation techniques. The strategy of

estimating several different models with different estimators gives us insight into the data quality and the importance of modelling dynamics and simultaneity.

First, we first estimate a static model using three different estimators using the fixed error, random error or between estimator. The static model functions as a nice benchmark to compare against more sophisticated models. This model is also employed by almost all other researchers in this field; cf. Appendix A.

Second, we analyse each variable that enters the model in order to asses the need for dynamic modelling. For this purpose we estimate for each variable an auto regressive model with one lag, AR(1). We use several available panel data estimators to be able to asses the validity of the results[9]. The auto-regressive estimations confirm the existence of massive auto-correlation in all variables implying that dynamic estimation and interpretation is preferable to static estimation in most cases. However, in some industries poor data quality makes it impossible to do anything else than static models.

Third, we estimate a dynamic model with one lag of the dependent variable and expand the model to include one lag of both the dependent and independent variables. We use several estimators, including the GMM-diff and GMM-SYS estimators, to take account for feed back and endogeneity. However, in the final estimations we do not allow for feed back for all explanatory variables. It turns out that allowing for much endogeneity - and too many instrumental variables - makes the results very unstable and dependent on the specific set of instrumental variables. In the estimations, we therefore primarily allow for the lagged dependent variable to be endogenous. However, we enter the Market Opening Milestones lagged once or twice since that reduces the problem of endogeneity from these variables.

We now continue our analyses by choosing the best of the models in order to conduct a number of more refined estimations. By using a *general-to-specific* approach, we end up with a parsimonious *final* model. The approach includes swapping the factors with the original Market Opening Milestones (MOMs) and Market Opening Index (MOI), including functions of the factors such as interaction and squared terms and including indicators of market structure. Below, we give a brief description of the steps in the general-to-specific approach:

1. We choose our benchmark model, either as static or dynamic model. The benchmark model includes all variables that are expected to explain the dependent variables (i.e., input prices and input factors, other control variables and market outcome variables). We also include the factors from the factor analysis. Finally we perform a *Wald*-test for the joint exclusion of insignificant input or control variables.
2. We formulate the model without the insignificant variables, and add the Market Opening Index instead of the two factors.
3. We formulate the same model as in step two, but now we include the individual Market Opening Milestones instead of the Market Opening Index. We test for the joint exclusion of some or all milestones.
4. We formulate the same model as in step two, but now we include products of the factors included (i.e., Factor 1 squared, Factor 2 squared and Factor 1 times Factor 2). We test for the joint significance of the three factor products.
5. We formulate the final model based on the best results in the previous steps. The *final* model either includes one or two factors, the Market Opening Index, or one ore more Market Opening Milestones. We correct for extreme outliers in the residuals by including dummies in the model, if necessary.
6. If the final model is dynamic we calculate the long-run parameters.

[9] We use the FE (fixed effects), FD (first difference) and GMM-type estimators.

7. In the final model we conduct three auxiliary regressions to investigate whether the strategy of market opening, (7a), initial sectoral conditions (7b), or regulatory governance (7c) has any impact on the link between market opening and performance.

As with all estimations, the number of observations might pose a serious limit to what we are able to carry out. Estimating dynamic models increases data requirements significantly since variables enter with time lags. Taking account of simultaneity using instrumental variable estimation also increases data requirements because we search for instruments among the lagged variables. Furthermore, this is a strategy that raises requirements for consecutive data observations.

We therefore aim to follow the steps outlined in the check list above, but it is not certain that all the steps make equally sense in all cases. For example, we may not be able to estimate valid dynamic models due to data limitations and in this case we have to resort to static models as the best feasible alternative.

## 3.3. Summarising the sectoral results

How did market opening perform? Did market opening in network sectors in EU15 member states in the nineties tend to decrease prices and increase productivity? In short, the answer is yes. In most of the final models market opening in various disguises turns out to be statistically significant determinants of sector performance with the expected sign: Negative in the case of prices, positive in the case of productivity.

We estimated price and productivity equations in nine separate network industries splitting out rail transport in passenger and freight transport and telecom in fixed and mobile making 18 potential final models. We failed to identify a final model in the case of gas productivity, due to unavailability of a proper productivity measure[10], ending up with 17 valid final models.

In the 17 final models we identified 23 significant variables capturing market opening. Out of this total 18 variables or almost 80 percent were significant and had the expected sign. One of the variables were not highly significant but had the expected sign. The remaining four variables were significant but had the wrong sign, cf. Table 3.2. The variables with significant but wrong signs were all identified in network industries with limited data availability. For example, in the urban price equation we had only 25 observations. In contrast, the results from electricity, telecommunications and rail freight are in particular convincing, since the results fulfil expectations with respect to sign and significance in both price and productivity equations and the estimations are often based on a significantly higher number of observations. See chapters 6-13 in section II for a detailed account of the results in each network industry.

[10] The analysis of productivity changes in the gas is made difficult because of the unavailability of data. We have tried using the gas throughput and distribution losses as a proxy for productivity. More traditional productivity measures such as labour productivity is not possible to construct since neither employment data nor value added data is reported for the gas sector alone. In all available EU statistics the gas sector is as a minimum joined with the electricity sector making the comparison of labour productivity over time and between countries impossible.

## Table 3.2: Sign and significance in performance equations

| | Price | | | | Productivity | | | |
|---|---|---|---|---|---|---|---|---|
| **Sector** | Market opening variable | Explanation | Negative expected sign? | Significant? | Market opening variable | Explanation | Positive expected sign | Significance |
| **Electricity** | MOM2 | Unbundling transmission | Yes | Yes | MOM2 | Unbundling transmission | Yes | Yes |
| | | | | | MOM9 | Congestion management | Yes | Yes |
| **Urban** | MOM1 | Separation of planning and operations | Yes | Yes | MOI | All | No | Yes |
| **Rail (pass)** | MOM8 | PSO compensation | Yes | Yes | MOM7 | PSO agreement | Yes | Yes |
| | | | | | MOM8 | PSO compensation | No | Yes |
| **Rail (freight)** | MOM6 | Price controls | Yes | Yes | MOM6 | Price controls | Yes | Yes |
| | | | | | MOM7 | Legal opening | Yes | Yes |
| **Telecom (mobile)** | MOI | All | Yes | Yes | MOM5 | Ownership | Yes | Yes |
| **Telecom (fixed)** | F1 | TPA, unbundling | Yes | Yes | MOI | All | Yes | Yes |
| **Air** | MOI | All | Yes | No | MOI | All | Yes | Yes |
| **Gas** | MOM3 | Ownership | Yes | Yes | n.a. | n.a. | n.a. | n.a. |
| | MOM7 | Access prices | Yes | Yes | | | | |
| | MOM8 | Price regulation | No | Yes | | | | |
| **Postal services** | F1 | Extent of openness to competition | Yes | Yes | F2 | Unbundling, TPA, free entry | Yes | Yes |
| | F2 | Unbundling, TPA, free entry | No | Yes | | | | |

Notes: Green indicates that the estimated parameter has the expected sign and is significant. Yellow indicates that the estimated parameter has the expected sign but is insignificant. Red indicates that the estimated parameter has the wrong sign and is significant. It was not possible to end up with a final model for gas productivity due to lack of a suitable productivity variable

Source: Own calculations on Copenhagen Economics, Market Opening Milestones database

Apart from establishing significant links between market opening and performance we also wanted to identify (if possible) the most important market opening policies. In our context we want to identify those Market Opening Milestones that are more important than others.

In some network industries we fail to identify single Market Opening Milestones that are more important than others. In particular, we cannot identify specific policies when the final model includes aggregate indicators of market opening instead of individual market opening milestones. This is the case for the final price models in telecom, air transport and postal services as well as the final productivity models in urban transport, telecom, air transport and postal services. In all these cases either the aggregate Market Opening Index or latent factors are the key significant variable capturing the impact of market opening. If the Market Opening Index is the key significant variable all Market Opening Milestones are by definition important as they all make part of the Index. If a single latent factor is the key significant variable all Market Opening Milestones being part of the latent factor are highly correlated and jointly important.

In other network industries we can in principle identify a single or a limited number of Market Opening Milestone(s) as the key significant market opening variable. For example, in electricity the milestone representing *Transmission unbundling* (MOM 2) is tested to be significant with the correct sign in both price and productivity equations. In other sectors as rail passenger, rail freight and gas we also find that the same (set of) milestone(s) enter both the final price and productivity model. We may interpret these results as evidence of specific market opening policies being the main drivers towards higher economic performance.

However, this is a dangerous and naïve interpretation. We strongly emphasize that having found statistical evidence that a specific milestone causes significant changes in economic performance should not be used to advocate specific policies only in this area because of severe *multicollinearity* between the Market Opening Milestones. Since the milestones are highly correlated with each other, it is very difficult to isolate the impact of particular milestones on economic performance. The impact attributed to one milestone may actually be the joint impact of this milestone together with other highly correlated milestones. For example, the parameter estimate for a single milestone may be, say 0.10 and for another milestone 0.25. But if these two milestones are highly correlated it might just as well be the other way around. See also Box 3.1 for a more detailed example of the multicollinearity problem.

**Box 3.1. An example of multicollinearity**

Individual Market Opening Milestones are often highly correlated making it difficult to distinguish their importance for performance. This is because the econometric regressions cannot identify the source of the impact if two milestones are correlated and changes their values at the same time. For this reason, the estimated parameter to a single Market Opening Milestone in the final model may not only reflect the impact of that particular milestone but also of the milestones to which it is correlated. This fact invalidates a strict interpretation of the role of the milestone in the final model.

An example is electricity, where the milestone *Transmission unbundling* is statistically significant in both the final price and productivity model. Factor analysis shows that the nine milestones in electricity can be divided in two separate groups of milestones with high correlation within groups but limited correlation between groups, cf. Table 3.3. Six milestones, including *Transmission unbundling,* make part of factor one, and three milestones make part of factor 2. All the six milestones in factor 1 are correlated with a correlation parameter above 80 percent.

**Table 3.3: Estimating the factors in electricity, EU15 member states**

| Market Opening Milestones | Factor 1 | | Factor 2 | |
|---|---|---|---|---|
| | Correlation | Weight | Correlation | Weight |
| Choice of supplier | 0.87 | 0.18 | 0.09 | 0.00 |
| Transmission unbundling TSO | 0.86 | 0.17 | 0.38 | 0.07 |

| | | | | |
|---|---|---|---|---|
| Third Party Access transmission | 0.83 | 0.16 | 0.41 | 0.08 |
| Third Party Access distribution | 0.83 | 0.16 | -0.10 | 0.01 |
| Wholesale trading | 0.80 | 0.15 | 0.24 | 0.03 |
| Congestion management | 0.84 | 0.16 | -0.10 | 0.01 |
| Distribution unbundling DSO | 0.36 | 0.03 | 0.58 | 0.17 |
| Pricing of Third Party Access | 0.02 | 0.00 | 0.74 | 0.27 |
| Ownership of generation | 0.13 | 0.00 | 0.87 | 0.37 |
| Total variance explained | 4.34 | | 2.04 | |

Note: The estimation method is principal component factor (PCF) and the correlations (or loadings) are rotated using the Varimax principle whereby each milestone will tend to be related to only one factor. Weight indicates normalised squared correlations.
Source: Calculations on Copenhagen Economics, Market Opening Milestones database, Copenhagen Economics (2004).

We have also explored the transmission mechanism between market opening and improved performance. Does market opening work by attracting new entry, changing the market structure, and getting better performance? Or does market opening work by the incumbent fending of potential new entry by lowering prices or improving productivity, thus improving performance without changing in the market structure? In short, is actual entry needed for market opening to work or is potential entry sufficient?

To answer these questions we have estimated an auxiliary equation with market structure as the dependent variable and market opening and other variables as the explanatory variables. We conclude that changes in market structure is an important driver of market opening (market opening in it self may still be important) if market structure is significant in the final model *and* market opening is significant in the auxiliary equation. On the other hand, we conclude that the market opening in itself is enough to improve performance if market structure is insignificant in the final model *and* market opening is insignificant in the auxiliary equation. If the analyses do not live up to these criteria, we conclude that it is not possible to say whether changes in market structure are a prerequisite for better performance or not.

Based on these criteria, we find that changes in market structure are important for achieving higher productivity in mobile telecommunications, cf. Table 3.4. On the other hand, changes in market structure do not seem to affect the gas prices. These two are marked with a dark grey shade in the table.

**Table 3.4. Are changes in market structure necessary to achieve better performance?**

| | | | |
|---|---|---|---|
| Significant | Tele fixed (price)<br>Tele mobile (price)<br>Tele fixed (prod)<br>Urban (prod) | Urban (price)<br>Rail freight (prod)<br>Rail freight (price) | Tele mobile (prod) |
| Indefinite | Electricity (prod)<br>Electricity (price)<br>Post (price) | Post (prod) | |
| Insignificant | Gas (price) | Rail pass (prod) | Rail pass (price) |
| **Market Structure/ Performance model** | Insignificant | Indefinite | Significant |

Note: In the vertical dimension we classify the auxiliary regressions of market structure on market opening latent factors. In the horizontal dimension we classify the performance equations, i.e. price and productivity equations, including both market structure and a market opening representation – our interest is solely on the parameter of market structure. The following guidelines have been used for the classification: 'Significant' refers to parameter estimates having the expected sign and being significant at a 10% significance level. 'Insignificant' refers to parameters being clearly insignificant (irrespective of sign). The category 'Indefinite' includes all other cases with wrong signs and/or close to significance (a P-value above, but not far from 10%). For example, the upper right cell requires both the auxiliary market structure and the performance regression to be significant and with correct sign.

Other cells in the table carry a brighter shaded grey, implying that they are borderline cases. For rail transport of freight and urban transport it *could be* that changes in market structure improves performance. Similarly, for electricity, postal prices and rail passenger transport productivity, the analyses indicate that changes in market structure alone are not enough to improve performance. For the remaining sectors not shaded it is not possible to say whether changes in market structure are a prerequisite for better performance or not.

We also investigate whether initial conditions have been important for the impact of market opening on performance. The question, however, turned out to be very difficult to analyse as data is very limited in the early years of market opening. We have tried to incorporate simple indicators of the initial state of market opening in the econometric models but have in most cases failed to find a significant link. However, this should not be interpreted as evidence that initial conditions do not matter.

Furthermore, we looked into the possibility that different reform strategies towards market opening might have had an influence the impact of market opening on performance. We identified different reform strategies in two dimensions, speed (how fast member states have implemented market opening) and timing (whether member states implemented market opening early or late in the period 1990-2003). In general, we find no evidence of specific reform strategies affecting the impact of market opening on sector performance conditional on the level of market opening achieved. This implies that what matters for the economic performance of network industries is to achieve a certain level of market opening, not to achieve this level fast or early. However, the earlier this level is achieved the earlier come the economic benefits.

Finally, we by and large fail to find a link between regulatory strength and performance. This may, however, be a result of an overly simplistic incorporation of the variable in the econometric model. An exception is electricity where we have a direct measure of the independence of the regulatory agency. We find evidence that member states with an independent electricity regulator have lower prices than member states without an independent regulator conditioned on the level of market opening.

# Chapter 4 Forecasting the impact of market opening

The objective of this chapter is to *forecast* the economic impact on prices and productivity that has been caused by the market opening that has occurred during the past 10-15 years in EU15 network industries. We use the word forecast to stress that the focus in this chapter is to determine the best numeric estimate of the impact of market opening. This focus is different from the focus in the previous chapter on the identification of the most important (significant) market opening polices in a parsimonious model. We use the forecasts presented in this chapter to calculate short- and long-run price and productivity shocks that enable us to simulate the economy-wide effects in the simulation model to be presented in Chapter 5.

The forecasting exercise is to a large degree based on the same econometric assumptions as in Chapter 3. We make use of the same set of static and dynamic panel data models based on the same standard Cobb-Douglas technology with the same basic choices of dependent and explanatory variables. However, the need to obtain precise forecasts require us to make somewhat different choices regarding 1) the representation of market opening; 2) the choice of econometric model, and 3) the choice of certain right hand side variables.

*The first choice* concerns the representation of market opening in the econometric models. For forecasting we prefer latent factors because they represent a very significant part of the total available information; because they give rise to unbiased forecasts avoiding the serious problems of multi-collinearity; and because they have statistically superior forecasting ability.

The alternative would be to use the entire set of Market Opening Milestones. However, milestones are plagued by problems of multi-collinearity. We do not know whether the estimated parameter to a specific market opening milestone also captures the impact of other strongly correlated market opening milestones. This gives rise to an error because we calculate price and productivity shocks by associating the change in market opening for a given milestone with the estimated parameter for the same market opening milestone only, not taking into consideration all other milestones.

*The second choice* concerns the use of the relevant econometric models. For forecasting we prefer to base our numerical forecast on the average forecast for a considerable number of suitable estimations in related econometric models, rather than relying on the point estimate from a single estimation in a single econometric model. The reason is that the necessary distinction between short- and long run impact forces us to structure the estimations differently and limits our freedom to choose the best model, and that in our often preferred model, the dynamic model[11], even small changes in the parameter determining the speed of adjustment

[11] We prefer dynamic models because our estimations show that an adjustment process takes place from the initial impact of market opening to the full impact of prices and productivity has been achieved.

causes large differences in both the estimated short- and long-run impacts[12]. Moreover, it allows us to assess the general uncertainty inherent when relying on just one estimated impact. This approach includes information from a range of estimators suitable for the purpose of forecasting with panel data.

We find that different estimators produce a smaller spread for the short-run impacts than for the long-run impacts reflecting higher uncertainty of the long-run impacts than the short-run impacts. We therefore report minimum and maximum values for the long-run impacts while only point estimates for the short-run impacts.

The instability of the long run results is primarily due to extrapolation. Extrapolation, as opposed to interpolation, is when values for market opening used to calculate the impacts are not represented in the data sample that went into estimating the econometric model. Especially for telecommunications and electricity, market opening increased dramatically in the years 2000-2003 which leads to predictions of strong impacts on performance in the future years (long-run). But data for the econometric models often ends in 2000/2001 meaning that the dramatic increase in market opening is not reflected in the econometric model. Had it been, the estimated long-run impact from market opening might very well had been smaller.

*The third choice* concerns the modelling of technological advance. For forecasting we prefer to model technological advance by a time- and industry-dependent dummy variable that is similar for all member states within a network industry. The underlying assumption is that technological advances dissipate at the same speed to all member states such that the impact on prices and productivity is the same.

The choice implies a more conservative forecast than the alternative, an explicit modelling of technological progress. The reason is that all direct measures of technological advance are very imperfect and biased proxies of true technological advance. Using these proxies often leads to estimates that are biased upwards. The reason is that market opening has taken place side by side with the technological development in many sectors, e.g. in telecommunications, which means that estimated impacts due to market opening may partly reflect effect which in reality originate from technological advances. By including the dummy variables we tend to find smaller impacts, because the dummy variables now captures part of the impact originating from market opening.

In the rest of this chapter, we first present the three choices in greater detail. Then we present the actual estimated short- and long–run impacts that form the core of the price and performance shocks to be sent to the simulation model. In the last section of this chapter we look closer at the similarities of the forecasting models preferred in this chapter and the identification models preferred in the previous chapter.

## 4.1. Choosing factors to represent market opening

The purpose of this part of the econometric analysis is to find precise forecasts of the economic impacts that will enter the simulation model in Chapter 5. This has implications for the choice of indicators representing market opening, i.e. whether the Market Opening Index, Market Opening Milestones or the latent factors are the best variables to include in the forecasting model. The overall conclusion is that the latent factors are preferable, since they avoid all multicollinearity problems and have superior forecasting abilities. In the following we will deal with the pros and cons of using different indicators of market opening for forecasting.

[12] We also use static models since it turns out that some static models yield short-run estimates and others yield long-run estimates, cf. Pesaran and Smith (1995).

We start by excluding the Market Opening Index. The only advantage of including the Index in the forecasting model is that it is an aggregate measure of market opening maximizing the degrees of freedom. But the aggregation weights are not a result of estimation (but guesstimation), implying that the model would be subject to a set of arbitrary restrictions. In other words: The Market Opening Index is likely to be too aggregated in a data-inconsistent way. Regression results also gave many examples of insignificance when including the Index. For this reason we do consider the Market Opening Index further.

To accurately forecast the impact of market opening, we need to base the forecast on the maximum amount of information. As a consequence, we have an initial preference for including all individual Market Opening Milestones. However, including all milestones could invalidate the forecasts because of multicollinearity. Roughly, we calculate the impact of market opening by multiplying the parameter estimate for a particular milestone by the change in the same milestone. However, if the estimated parameter to the market opening milestone in reality captures the impact of a number of other strongly correlated market opening milestones not taken into consideration when we calculate the shocks, we will make false forecasts. Multicollinearity also means that the estimated parameters to the Market Opening Milestones would (and do when estimated) possess large standard errors, implying that the exact size of the effects is highly uncertain. Uncertain estimates will naturally produce uncertain forecasts. Moreover, including all Market Opening Milestones would result in an unnecessary high reduction in the degrees of freedom.

The latent factors avoid through their construction the multicollinearity problem. Factor analysis assures that all highly correlated variables will be aggregated into one single variable and thereby only leave a new set of variables (latent factors) representing all the separate (uncorrelated) developments. Thus, the factors contain a large share of the relevant information but concentrated in only two variables.[13]

We could have used the final model from the previous chapter to make forecasts of the economic impact of market opening, but these forecast would obviously only be based on a limited information set. And more importantly, the forecasts will again be subject to high uncertainty, because the link between estimated parameter and corresponding milestones is disturbed by multicollinearity. Moreover, when excluding insignificant milestones we might have made some Type II errors (wrongly excluded some truly important milestones due to low power caused by the small sample), because we where overly concerned with keeping the rate of Type I errors low (wrongly retaining some truly inconsequential milestones in the model). These concerns were appropriate because we wanted to be careful in our policy conclusions, avoiding the risk of recommending market opening policies without any true impact. Now, the picture is reversed and we are willing to include every piece of information available and let model and data resolve how best to utilize it. For this matter our factor analysis approach is suitable. It bypasses the severe problems we encountered with respect to multicollinearity, while allowing us to virtually include all milestones in the estimations.

Behind the preference of including more information by means of latent factors there is an important statistical argument. Below we use statistical methods to find out whether a model based on latent factors as preferred in this chapter is a superior forecaster than the final model identified in the previous chapter. We find strong evidence that a model using latent factors produces superior forecasts compared to the best alternative.

[13] In section 3.3 we went into more detail on the multicollinearity problem. We can note that the factor analysis always resulted in two factors, which is a considerable reduction from 5-12 MOMs. In other words: most of the variation in all the MOMs can be retained in two variables, and this is only possible when the MOMs are highly correlated with each other.

We follow the standard procedure by comparing mean squared error (MSE) from two models calculated from a series of *simulated out-of-sample* estimations; that is where models are estimated with data prior to the forecasting period, cf. see Box 4.1[14]. Specifically, we use the preferred final model from chapter 3 to make the first set of forecasts. After making the first forecasts we simply substitute the milestones from the final model with the latent factors to obtain the second set of forecasts. As the final model is the best available parsimonious model this choice tend to favour the final model from chapter 3. Using a similar procedure for a model with latent factors we would probably find different and better representations than the one actually applied in the MSE-analysis. Despite this advantage for the final model based on milestones, we find that the model with latent factors systematically outperforms the final model with milestones.

The relative MSE is 0.96 for both electricity models and somewhat smaller for telecommunications productivity, meaning that the model with factors has a summarised MSE that is at least 4 percent smaller than the model with milestones, cf. Table 4.1. This is a rather substantial difference since the two models only differ with respect to the choice of factors and milestones. To interpret the size correctly one should remember that both the price and productivity model mainly are explained by the variation in the production inputs, capital and labour, and other control variables. Market Opening appears down the list in explaining the total variation of the dependent variable and a 4 percent difference is therefore rather substantial.

**Table 4.1. Comparing sum of MSE's in the two models by relative MSE.**

| Econometric model | Relative MSE |
|---|---|
| Electricity productivity | 0.968 |
| Electricity price | 0.958 |
| Total telecommunications – productivity | 0.841 |
| Total telecommunication price | n.a. |

Note: The table shows relative MSE that is the sum of MSE's from 1990-end year in the sample for the econometric model using single MOMs from the identification analyses divided by the sum of MSE's from 1990-end year in sample for the model using latent factors. A value below one signals that the model with factors is the best forecast. The model using milestones is the exact final model of the baseline analysis. The only difference between the final model and the factor model is the choice of variables to represent market opening, MOMs or factors.
Source: Copenhagen Economics.

As a concrete example consider the electricity productivity model: The explained variation ($R^2$) is around 0.75 with market opening included and around 0.71 without market opening in a dynamic specification. Thus market opening is not the main driver of productivity and obtaining an improvement in the total out-of-sample MSE of, in this case, 3.2 percent is rather surprising. The factors must be considerably better to forecast the impacts of market opening.

The better forecasting ability of the model using factors has two explanations. First, the factors represent more information on market opening than single milestones. This improves forecasting when in reality all milestones are important in explaining performance. Second, the variation[15] in individual milestones is small since single market opening policies only change a few times at most for each country over the period of investigation. Hence, the time series properties of individual milestones will be characterised by sudden "jumps" resulting in equally sudden "jumps" in forecasted performance. Since actual performance evolves more smoothly,

[14] The methodology is described in detail in Stock and Watson (1999).

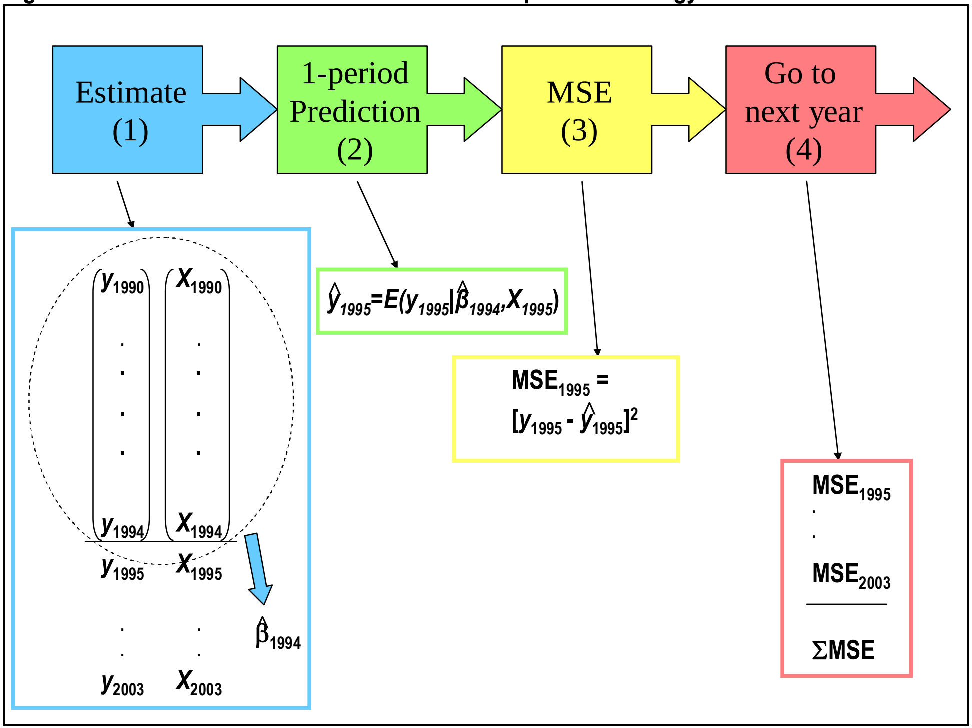
[15] "Variation" is the degree of change in a variable, in contrast to "variance" which gives a numerical measure of the size of the changes. Normally the two are interrelated, but high variance does not necessarily imply high variation and reversely.

this results in high values of the MSE's since they represent the difference between actual and forecasted performance.

**Box 4.1: How to calculate simulated out-of-sample forecast MSE**

The simulated out-of-sample methodology is illustrated in Figure 4.1.

**Figure 4.1. Illustration of the simulated out-of-sample methodology.**




Note: The figure illustrates the simulated out-of-sample methodology used to asses which of two models are better at forecasting.
Source: Copenhagen Economics

The figure illustrates the four stages of each iteration. At the first stage, the econometric model is estimated on the basis of the data from the period 1990-1994. Our data sample covers at most the years 1990-2003, so 1990 is the first year available. Estimating the model using data from 1990-1994 yields an estimated parameter vector $\hat{\beta}_{1994}$, belonging to *all* the explanatory variables in the econometric model, that is market opening variables and control variables.

At the second stage, this parameter vector $\hat{\beta}_{1994}$ together with the values of all the explanatory variables in 1995 is used to make a forecast of the performance variable (price or productivity) in 1995, $\hat{y}_{1995}$.

At the third stage, the mean squared error $MSE_{1995}$ is calculated by subtracting the actual value of the performance variable from the forecasted value.

At the fourth stage, the $MSE_{1995}$ is saved. A small value of $MSE_{1995}$ means that the model forecast is accurate because there is little divergence between actual and forecasted performance.

The iterative nature of the procedure means that after having concluded the fourth stage, we return to the first stage, only now the econometric model is estimated on the sample 1990-1995. The estimated parameter vector is now $\hat{\beta}_{1995}$. This estimate alongside the values of all the explanatory variables in 1996 is used to forecast the value of the performance variable in 1996. The $MSE_{1996}$ is calculated as the difference of the actual performance variable in 1996 and the forecasted value in 1996. Again the resulting $MSE_{1996}$ is saved and the procedure starts all over, this time using the sample 1997.

This iterative procedure continues until the second to last year. In this run, the performance variable in 2003 (if indeed the actual econometric model has that much data available) is forecasted and the $MSE_{2003}$ is found. The difference in stage four compared to the previous runs is that instead of starting all over at stage 1, we now add all of the MSE's from 1995 to 2003 into one number, the $\sum MSE$ in Figure 4.1. This is the crucial number reflecting the models ability to forecast. If this number is small then the model is good for forecasting.

However, one cannot compare the sum of MSE's to some canonised number thereby concluding that the model is good or poor at forecasting. Instead one can compare the $\sum MSE$ in two models. The one with the smallest $\sum MSE$ is better at forecasting.

Consequently, we compare the sum of the MSE's for the model with single MOMs, $\sum MSE^{MOM}$, with the MSE's for the model with factors, $\sum MSE^{factors}$ by dividing the two, which yields the relative MSE (using proper indices in the summation):

$$\text{Relative MSE} = \frac{\sum_{i=1995}^{end\ year} MSE_i^{factors}}{\sum_{i=1995}^{end\ year} MSE_i^{MOM}}.$$

If the relative MSE is less that one, then the model using factors to represent market opening is better at forecasting performance than the model using single MOMs

## 4.2. Assessing the robustness using several short- and long-run estimators

In this section we demonstrate how using a range of relevant econometric models and estimators increase the robustness and allows for a better assessment of the stability of the forecasted impact.

One could argue for using a single dynamic model and corresponding estimator since our estimations show, not surprisingly, that an adjustment process takes place from the initial impact of market opening to the full impact of prices and productivity. When adjustment occurs a dynamic model would be suitable. However, we show that even small changes in the parameter determining the speed of adjustment causes large differences in both the short-run and long-run estimated impacts. This is one reason why we choose to include several relevant models and estimators to assess the robustness of the impacts. Another is that we can better asses the general model uncertainty when using many models and estimators that should, ideally, give us the same impacts. Even though dynamic models are traditionally applied when time aspects are involved as here, we find that static models can actually reveal information on both the short-run and long-run impacts.

We find that different estimators produce a smaller spread for the short-run impacts than for the long-run impacts reflecting higher uncertainty of the long-run impacts than the short-run impacts. This leads us to conclude that long-run impacts are more uncertain than short-run impacts and we, therefore, choose to report minimum and maximum values for the long-run impacts while point estimates only, for the short-run impacts.

We use both dynamic and static models to assess short-run and long-run impacts. The dynamic models yield estimates on both the short-run and long-run. The same is true for static models, where the choice of estimator determines whether the estimates should be interpreted as representing the short-run or long-run.

*How to choose the point impact among many impacts*
We follow a rule of thump selection process when we choose the central estimate to be used in the simulation model. For the short run estimators we first seek estimation outliers in order to exclude extreme estimators from further consideration. We choose the best impact within the range of impacts.

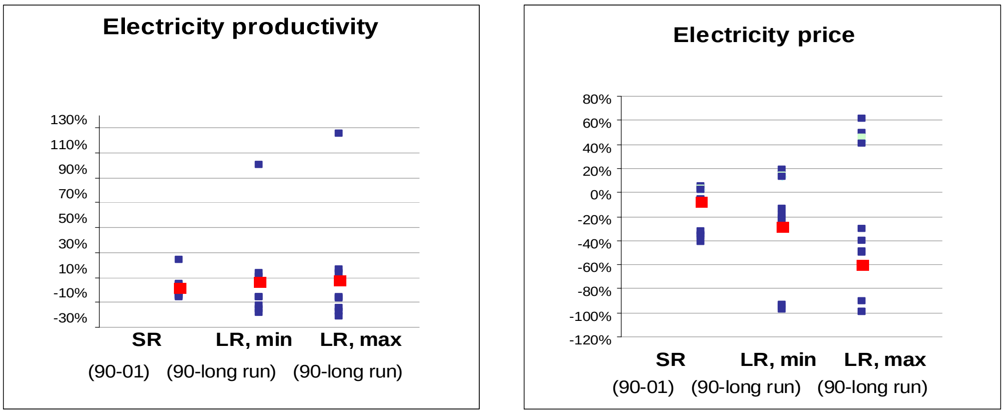
The best impact comes from a dynamic model estimated by GMM-SYS with time dummies when the adjustment parameter is large. In this case a dynamic model is called for and the GMM-SYS estimator should produce the most reliable estimates[16]. When the adjustment parameter is smaller or when the GMM-SYS estimator produces extreme impacts, we use a simple average of all the impacts produced by all the estimators. If both of these approaches result in extreme impacts, we simply pick the median estimator.

We present a minimum and a maximum for the long run impacts and a central estimate for the short run impact. The minimum long run impact is given by assuming that full adjustment to market opening has taken place in 2004. We choose the year 2004 because the latest observation on market opening is 2003 which affects prices and productivity in 2004. The maximum value is determined calculating the true (infinite) long-run impact of market opening.

*Precision of short run and long run impacts*
We find that the estimated short-run impacts are estimated with higher precision than the long-run impacts since the former produce smaller spreads than the latter. Figure 4.2 shows both short-run and long-run spreads for electricity. This illustrates what is generally the case for all the sectors.

The figure shows that for both productivity and prices the spread of estimates includes both negative and positive values. However, the best possible estimates using all available data are the point estimate in the figures. The point estimates for both short and long-run are the impacts that enter the CETM for the economy-wide analysis.

**Figure 4.2. Spread of impact estimates in Electricity productivity and price.**




Note: The figures show the spread of estimated impacts in electricity productivity and prices. The complete set of estimates comes from the numerous econometric specifications made to asses the stability of results. The highlighted, red dots are the point estimates singled out from this array of estimations to represent the impact from 1990-2001 (short run) and 1990-long run minimum and maximum values (long run). For both price and productivity the chosen impact is based on the GMM-SYS estimator. This is primarily because adjustment seems very

[16] For a description of various estimators, see Appendix A.

prominent in this sector, and secondly because the impact is close to the average and median impact of the spread, cf. the criteria for selecting estimators.
Source: Copenhagen Economics

An important reason for the low precision of the long-run estimated impacts is extrapolation, for which no remedy exists. Extrapolation, as opposed to interpolation, is when values of market opening used for forecasting price and productivity impacts are not represented in the market opening variables that went into estimating the econometric model. For example for some sectors, especially for telecommunications and electricity, market opening increased dramatically in the years 2000-2003 which leads to predictions of strong impacts on performance in the future years. But data for the econometric models often ends in 2000/2001 meaning that the dramatic increase in market opening is not reflected in the econometric model. Had it been, the estimated parameter reflecting the impact from market opening might very well had been smaller, producing smaller long-run impacts.

Another reason for the large long-run spreads is that all the long-run estimates primarily are projections of historical trends into the future. Negative short-run impacts in productivity will often translate into larger negative impacts in the long-run. And positive short-run impacts in productivity will often translate into larger positive impacts in the long-run, thereby creating an even larger spread[17].

The rest of the section describes the relationship between the different short-run and long-run estimators from and argues for the use of static models to complement dynamic models when assessing short-run and long-run impacts.

*The relationship between static and dynamic models*
When dealing with the time aspect as represented by the short and long-run dynamic econometric models are usually applied. A model is characterised as dynamic when the lagged dependent variable enters as an explanatory variable on the right hand side of the model. This is illustrated by the following (stylised) econometric model which is a general representation of the model for any of the network industries in this study:

*Equation 4.1*

$$y_{it} = \beta_0 + \alpha y_{it-1} + \beta_1 x_{it} + \beta_2^{dynamic} MarketOpening_{it}$$

The model is shown without an error term, *i=1,…,15 EU countries* and *t=1990-2002* (the maximum number of years in our study). $Y_{it}$ is the dependent variable, in our case either price or productivity. $X_{it}$ is an explanatory variable[18] while $MarketOpening_{it}$ is the variable representing market opening (e.g. the factors).

$\beta_2^{dynamic}$ is the parameter reflecting how market opening affects $y_{it}$,. $Y_{it-1}$ enters as an explanatory variable and $\alpha$ is called the adjustment parameter, because it reflects how performance adjusts from the short-run to the long-run. Thus, the dynamic model links different time periods together which is demonstrated by the following example: If the variable *MarketOpening* increases one unit at time *t*, the dependent variable *y* increases by $\beta_2^{dynamic}$ at time *t* – this is the short-run parameter. But since $y_{it-1}$ enters on the right hand side in the model, *y* increases by $\alpha\beta_2^{dynamic}$ at time t+1 and $\alpha^2\beta_2^{dynamic}$ at time t+2 and so forth. In the

[17] This is the general case. Moreover, the dynamic models tend to support these findings. However, the static short and long run model may produce opposite results and this information is included together with all other relevant information.
[18] In the actual econometric estimations several explanatory variables enter the model.

long run (time t + a very large number), the estimated parameter reflecting the impact[19] on y becomes:

$$\frac{\beta_2^{dynamic}}{1-\alpha}$$ [20].

In this study the dynamic panel data models are estimated using two general methods of moments (GMM) estimators – the GMM-diff and the GMM-Sys.

The estimated long-run impact is governed by two parameters in the dynamic model, the short-run parameter $\beta_2^{dynamic}$ and the adjustment parameter $\alpha$ . The adjustment parameter takes on values between zero and one[21]. When it is close to zero, the short-run and long-run parameters, and impacts, are almost identical, cf. the formula. The economic interpretation is that the full impacts of market opening appear almost immediately. When $\alpha$ is close to one, the long-run impact is much larger than the short-run impact, meaning that it takes time for the full effect of market opening to appear. However, even small changes in the adjustment parameter $\alpha$ , translates in to large differences in the long-run impact. If $\alpha$ for instance takes on the value of 0.80, the long-run effect is five times larger than the short-run effect. If instead $\alpha$ is 0.85–a small increase of 0.05–the long-run effect is now close to seven times larger than the short-run effect – a markedly stronger impact.

In other words, the long-run impacts are very sensitive to the size of the adjustment parameter. For this reason we look for auxiliary information on the long-run impacts, while it would of course also be of interest to have more information on the short-run impacts.

An obvious place to search for auxiliary information is in the static models. The static model equivalent to the dynamic model Equation 4.1looks like this:

*Equation 4.2*
$$y_{it} = \beta_0 + \beta_1 x_{it} + \beta_2^{static} MarketOpening_{it}$$

is a static model because the independent variable does not enter lagged as an explanatory variable on the right hand side. Consequently, no explicit link exists between the short and long-run.

$\beta_2^{static}$ reflects how market opening affects $y_{it}$,. Since no specific link exists between different time periods, the static model does not explicitly distinguish between short-run and long-run parameters, hence, $\beta_2^{static}$ does not reflect either one.

However, in a widely cited article from 1995 Pesaran and Smith find that parameters estimated on a cross section in a static model, could be interpreted as long-run parameters in the corresponding dynamic model[22]. Applying the between estimator to the static panel data model, achieves cross section estimates since the between estimator uses the variation between countries only (and not within countries)[23]. Using the symbols from the dynamic and static models it means that:

---

19 The size of the parameter estimates are intimately linked to the estimated impacts. The impacts are (basically) calculated by multiplying the parameter estimate with the actual size of market opening as reflected in e.g. the factors or the MOM's.

20 This is the formula for an infinite sum.

21 Not by definition, the value can also be negative but should always be numerical smaller than one. However, in these analyses the adjustment parameter is always positive and smaller than one.

22 Pesaran and Smith (1995).

23 See Johnston and DiNardo (1997) for more on the between estimator.

$$\beta_2^{static,between} \approx \frac{\beta_2^{dynamic}}{1-\alpha}.$$

Similarly, useful information on the short-run impacts is found in the same static model. When the first difference (FD) or fixed effects (FE) estimators is applied to the static model, the estimated parameters may be interpreted as short-run parameters in the equivalent dynamic model. Using the symbols from the dynamic and static models it means that:

$$\beta_2^{static,FD/FE} \approx \beta_2^{dynamic}.$$

Saying that FD and FE-estimators in static models estimate short-run parameters equivalent to short-run parameters in dynamic models, draws on the econometric literature dealing with times series econometrics. This literature consistently interprets the first difference (FD) estimator as a short-run estimator because these estimators use the variation from year to year (the short-run fluctuations). Since the fixed effects (FE) estimator ought to produce similar results as the first difference estimator in a panel data model, both of these estimators should consequently be interpreted as short-run estimators[24].

Summing up, we use both dynamic and static models to assess short-run and long-run impacts. For dynamic models we use the two estimators GMM-diff and GMM-Sys which estimate both short-run and long-run impacts, cf. Table 4.2.

**Table 4.2. Short-run and long-run estimators and models.**

| | Dynamic models | Static models |
|---|---|---|
| Short-run estimated impacts | GMM-diff, GMM-Sys | FD, FE |
| Long-run estimated impacts | GMM-diff, GMM-Sys | Between |

Source: Copenhagen Economics.

In static models the first difference (FD) and the fixed effects (FE) estimator estimate short-run impacts, while the between estimators estimate long-run impacts.

## 4.3. Capturing technological advance with dummy variables

It has been difficult to find appropriate indicators of technological progress. And since market opening has occurred during a time of strong technological advance, e.g. in telecommunications, there is a real risk that the estimated impact of market opening partly reflects technological advance. This is the reason why we prefer to model technological advance by dummy variables for each year as explanatory variables in the forecasting models. Because new technology spreads so fast, it is likely that technological advances will impact prices and productivity equally across countries. This is exactly what the dummy variable captures.

This section demonstrates how we avoid excessive estimates because the dummy variables capture part of the variation previously erroneously captured by market opening.

The econometric models for the sectors in the baseline analysis in the previous chapter include some measures of technology[25], however, no proper measures such as e.g. the number of innovations or the number of patents were found for all seven network industries.

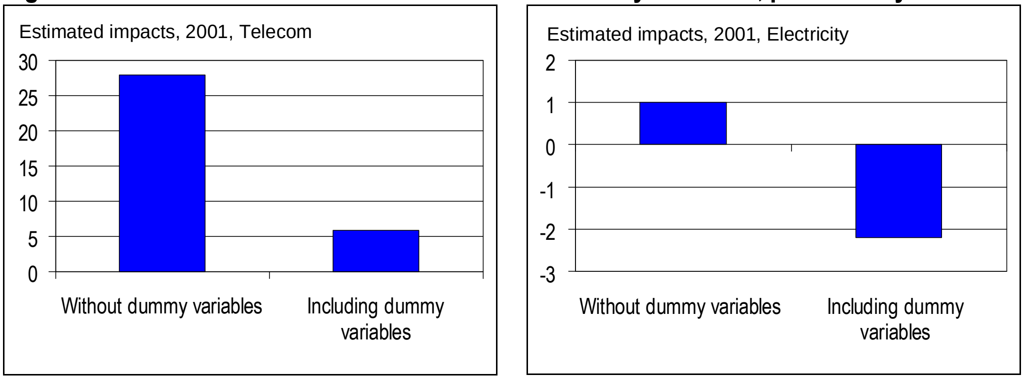
[24] In this study the FD-estimator is more likely to be better than the FE-estimator. This is because, when strong auto correlation exists in the variables, and this is the case in this study, panel data theory suggests that the FD-estimator is more reliable than the FE-estimator.

[25] In telecommunications, different proxies for capital stock were included that may be interpreted as technological advances, for instance share of digital lines. However, no completely satisfactory measure was found. For the other sectors it was even more difficult to find measures for technological advances.

Realising the difficulties in obtaining consistent data in this area, we model technological advances by including dummy variables for each year as explanatory variables in the econometric models. Because new technology today spreads so fast, it is reasonable to assume that technological advances will impact prices and productivity fairly equally across countries. This effect is captured by the dummy variables. However, it should be stressed that dummy variables used to capture technological advances is no superior approach either. We simply consider it to be a fair solution to a challenge not easily addressed.

We find that the impact from market opening on performance is generally reduced when the dummy variables are included. This is especially the case for telecommunications which has also experienced strong technological advances, cf. Figure 4.3.

**Figure 4.3. Short-run estimates with and without dummy variables, productivity.**




Note: The figures show an average of the estimated impacts for estimations with and without yearly dummy variables that are included to capture technological advances. The average of the impacts may not precisely equal the estimated impact used as inputs to the CETM. The latter also put some weight on the theoretically better estimator. The first figure is telecom productivity and the second is electricity productivity.
Source: Copenhagen Economics.

The figures show the average of several short-run parameter estimates with and without the dummy variables. The estimated impacts without the dummy variables are on average higher than the estimates including the dummy variables.

This indicates that the estimated impacts on performance from market opening without the time dummies are probably overstated, because they also reflect some of the impact from technological advances. However, we do not disregard the estimated impacts from models without dummy variables, altogether. Both are used, to secure robustness of the results as explained in the previous section, because the estimated impacts with dummy variables may actually understate the impact from market opening.

The estimated impacts from models with dummy variables may “go too far” and capture aspects of market opening. This is a real possibility, because market opening has not increased smoothly, rather it has occurred in jumps in certain years, which is what the dummy variables capture. This may be the reason that impacts for electricity including the dummy variables are even negative, cf. figure 4.3.

## 4.4. Summing up the econometric choices

The next section presents the estimated impacts, the result of econometric estimations based on econometric panel data models with the three specific choices of 1) market opening, 2) models and estimators and 3) technological advances; as described in the previous part of this chapter.

The choices lead to the following productivity and price models used for estimating impacts on productivity and prices due to market opening:

*Equation 4.3: Productivity*

$$\ln Y_{it} = \alpha^{y} \ln Y_{it-1} + \gamma_{K}^{y} \ln K_{it} + \gamma_{L}^{y} \ln L_{it} + Z_{it}^{y} \gamma_{z}^{y} + M_{it} \beta_{M}^{y} + F1_{it} \beta_{1}^{y} + F2_{it} \beta_{2}^{y} + \delta_{t}^{y} + \eta_{it}^{y}$$

*Equation 4.4: Price*

$$\ln P_{it} = \alpha^{p} \ln P_{it-1} + \gamma_{K}^{p} \ln\left(P^{K} \frac{K}{Y}\right)_{it} + \gamma_{L}^{p} \ln\left(P^{L} \frac{L}{Y}\right)_{it} + Z_{it}^{p} \gamma_{z}^{p} + M_{it} \beta_{M}^{p} + F1_{it} \beta_{1}^{p} + F2_{it} \beta_{2}^{p} + \delta_{t}^{p} + \eta_{it}^{p}$$

where $i$ refers to country, $t$ to years, and all $\alpha$'s, $\gamma$'s and $\beta$'s are parameters to be estimated. $\delta$ represents the time dummies to be estimated capturing technological advances. $Y$ is value added, $P$ is prices, $K$ physical capital, $L$ labour, $Z$ a vector of control variables and $M$ a vector of market structure variables. The two composite expressions in the price equation with P, K, Y and L) represent cost of capital and cost of labour, respectively. The variables of main interest are the factors, $F1$ and $F2$. $\eta_{it}$ is a randomly distributed zero mean error term.[26] Notice, that in the static models the lagged dependent variable will be excluded.

## 4.5. Results of the forecast analysis

In this section we present the estimated impacts in the short-run and long-run in the seven network industries. These impacts will enter the Copenhagen Economics Trade Model (CETM) for the economy wide analysis.

We find that electricity generation, telecommunication, rail freight transport and air transport has experienced higher productivity and lower prices as a result of market opening in both the short and long run, cf. Table 4.3. For example productivity in total telecommunications is expected to have risen around 24 percent, while price have dropped by 22 percent from 1990-2001.

**Table 4.3 Impact from market opening, EU15 average.**

| EU15 | Productivity impact | | | Price impact | | |
|---|---|---|---|---|---|---|
| | 1990-2001 (short run) | 1990-Long run (long run) | | 1990-2001 (short run) | 1990-Long run (long run) | |
| Sector | Percent | | | | | |
| | | Min | Max | | Min | Max |
| Air | 13.2 | 15 | 17 | -2.3 | -2 | -2 |
| Electricity | 2.3 | 7 | 8 | -7.6 | -28 | -60 |
| Gas | - | - | | -1.0 | -4 | -5 |
| Postal services | 28.1 | 36 | 37 | 4.2 | 7 | 8 |
| Rail, freight | 46.7 | 83 | 261 | -24.9 | -26 | -26 |
| Rail, pass. | -6.6 | -9 | -12 | -21.9 | -26 | -27 |
| Telecom, total | 23.8 | 57 | 75 | -22.2 | -34 | -35 |
| Telecom, mobile | 93.2 | 153 | 383 | -20.5 | -39 | -43 |
| Urban | 1,0 | 2 | 6 | 2.2 | 4 | 6 |

Note: The table presents the estimated impacts of market opening in all seven network industries. The column 1990-2001 reflects market opening from 1990-2000 since the econometric models include market opening with a one period lag, whereby market opening in 2000 affects prices and productivity in 2001. The column

[26] We suppressed the constant terms.

1990-long run reflects the "infinite" long-run effects of market opening up to 2003 which is the latest observation. Values in the column 1990-2001 are used for "short run" in the model analysis in Chapter 5. The values in the column 1990-long run are used for "long run" in the model analysis in Chapter 5. The impacts are weighted averages for the EU 15 member states. The full set of estimated impacts are found in appendix D.

Source: Copenhagen Economics.

For urban transport, rail passenger transport and postal services some of the estimated impacts are counter intuitive. Either prices have risen or productivity has fallen or both. The reason for these counter intuitive impacts may be poor data availability for the econometric estimations which would produce unreliable impacts. This is partly confirmed by the few observations available in some of the sectors. In urban transport only 25 observations are available for estimating the impacts on prices. For rail passenger transport only 66-80 observations are available for estimating the impacts on both prices and productivity and in postal service only 64 observations are available for the prices estimations. The reader could also recall the findings of Chapter 3, where insignificant and sometimes counterintuitive results were found in exactly the same sectors.

Another possibility is that the impacts are true; that market opening has not lead to lower prices and higher productivity. The high market shares of the incumbent close to 100 percent for most countries in urban transport, rail passenger transport and postal services lend some support for this possibility as well.

**Box 4.2: How to calculate the impacts from market opening**

In this box we will explain how the economic impacts were calculated. We will only refer to the price model, since the calculations are completely similar for productivity.

The price equation consists of number of explanatory variables among which we also find the latent factors representing market opening. When estimated we obtain three important parameter estimates: $\hat{\alpha}$ the parameter on the lagged dependent variable accounting for the dynamics; $\hat{\beta}_{F1}$ and $\hat{\beta}_{F2}$ the parameter estimates of the factors. Notice, that since we take the natural logarithm of prices the latter parameter estimates can be interpreted as semi-elasticities telling how many percent prices fall (or rise) when market opening increases by one unit, i.e. from zero to one.

Moreover, we have time series of latent factors for each country, $F1_{it}$ and $F2_{it}$. Suppose that factor 1 changes in country *i* between two years *t*-1 and *t*. Then the immediate effect on prices is calculated as:

$$\%\Delta P_t = \frac{P_t - P_{t-1}}{P_{t-1}} = \exp\{\hat{\beta}_{F1}\Delta F1_{it}\} - 1$$

where $\Delta$ refers to a change between consecutive time periods. Since, the model also accounts for dynamic adjustments there will be an additional impact in the next year *t*+1:

$$\%\Delta P_{t+1} = \alpha \cdot [\exp\{\hat{\beta}_{F1}\Delta F1_{it}\} - 1]$$

and so forth for the following years, implying that the additional impact in year *t*+*k* from the change in factor 1 in year *t* is:

$$\%\Delta P_{t+k} = \alpha^k \cdot [\exp\{\hat{\beta}_{F1}\Delta F1_{it}\} - 1].$$

Realising that we have two latent factors and that they may change every year, we have to sum over factors and time periods in order to obtain the percentage change from the base year, 1990, and the year of interest, *K*, which for instance could be 2001. Thus, the final formula is:

$$\%impact_{1990+K} = \sum_{t=1990}^{K} \alpha^{t-1990} \cdot [\exp\{\hat{\beta}_{F1}\Delta F1_{it}\} + \exp\{\hat{\beta}_{F2}\Delta F2_{it}\} - 2].$$

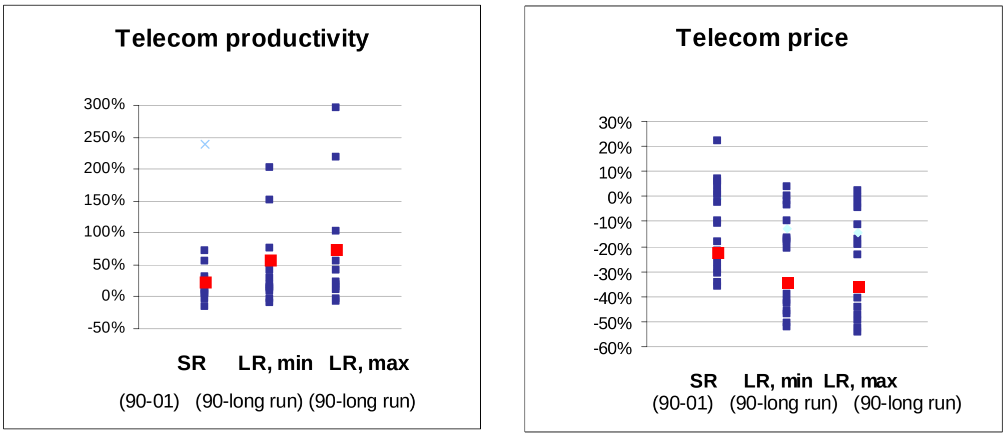
The long run impacts are found by setting $K = \infty$.

The attentive reader will notice that there is a problem of summing percentage changes over years, because the reference year changes from period to period. In the actual calculations we also take this into account, but for simplicity of exposition we did not include it here.

The long-run estimated impacts (in the table "1990-long run") are generally stronger than the short-run impacts, and with a fairly small spread, except for electricity prices and telecommunications productivity where the spreads are larger. The small long run spreads in many sectors presented in the table, could lead to the false conclusion that the long-run impacts are estimated with high precision. The long-run impacts are in fact estimated with fairly low precision. The small upper and lower bounds merely reflect our best long-run "point" estimate which we use in the economy-wide analysis in Chapter 5 along side the short-run impacts from Table 4.3.

The estimated impact in the short-run (1990-2001) represents the best point estimate in a larger spread of estimates. The same goes for the long-run "point" estimate which also lies within a larger range. This is demonstrated for telecommunications in Figure 4.4.

**Figure 4.4. Point estimates and spread of estimates, total telecommunications.**




Note: The figures show the spread of estimated impacts in telecommunications productivity and prices. The complete set of estimates comes from the numerous econometric specifications made to asses the stability of results. The highlighted, red dots are the point estimates singled out from this array of estimations to represent the impact from 1990-2001 (short run in the model analysis) and 1990-long run (long run in the model analysis).
Source: Copenhagen Economics

*Level of significance for the forecasted impacts*

The estimated impacts in Table 4.3 are not shown together with a level of significance. This is because significance and insignificance has already been established in Chapter 3 for models where single MOMs were included for market opening[27]. Nevertheless, we proceed by presenting the levels of significance for the estimated impacts using the factors.

Since the impacts rest on several estimations using different models and estimators, it is not surprising that we find that the factors are not significant in all of the single regressions. More surprising is it, that we actually often find significant estimates, cf. Table 4.4. For example, we estimated the electricity price model 28 times including factor 1 and out of these the factor 1 parameter estimate turned out significant 13 times. Not only in these sectors, but in general the frequency of significance is much higher than what would be induced be pure coincidence.[28]

[27] The estimation results are found in the sectoral analyses in Part II of this report.

[28] Statistical theory teaches us that keeping a 10% significance level implies having 10% probability of falsely rejecting a true null hypothesis. In other words: On average, in one out of ten tests one would falsely point to significance.

**Table 4.4: The frequency of significance for the latent factors**

| | | Factor 1 (F1) | Factor 2 (F2) |
|---|---|---|---|
| Electricity | Productivity | 4 (14) | 4 (14) |
| | Price | 13 (28) | 8 (25) |
| Tele mobile | Productivity | 1 (12) | 10 (15) |
| | Price | 26 (35) | 23 (32) |
| Tele overall | Productivity | 17 (31) | 4 (24) |
| | Price | 14 (29) | 17 (34) |
| Urban | Productivity | 2 (14) | 5 (14) |
| | Price | 2 (8) | 1 (7) |
| Rail passenger | Productivity | 2 (12) | 1 (12) |
| | Price | 2 (12) | 0 (11) |
| Rail freight | Productivity | 4 (12) | 5 (12) |
| | Price | 5 (12) | 7 (11) |
| Postal services | Productivity | 5 (9) | 6 (9) |
| | Price | 4 (9) | 2 (9) |
| Air | Productivity | 2 (10) | 2 (10) |
| | Price | 2 (10) | 2 (10) |
| Gas | Price | 1 (9) | 4 (9) |

Note: The table states the number of times the regressions returned statistical significant estimates of the given factor at the 10% level. The number in parenthesis is the total number of regressions. The regressions mainly differed with respect to estimation method and inclusion/exclusion of time dummies. The reason why the number of regressions are not perfectly the same for the two factors, is that a few times the a factor was very insignificant while at the same time having a very small parameter estimate which caused us to re-estimate with the other factor only. This is why electricity price are estimated 28 times with factor 1 and only 25 times with factor 2.
Source: Copenhagen Economics.

We find that the factors point to significant estimates in many cases. In particular we find that in the sectors electricity, telecom and rail freight the evidence on significant effects is most pronounced. On the other hand Table 4.4 also tells that the obtained parameters are sensitive to the estimation procedure since we do not *always* find significant estimates corresponding to the sectors where significance has already been established in Chapter 3.

There are two main reasons for why the evidence on significance is not as overwhelming as in Chapter 3.

*First* and most important, we always include both factors, even when only one of them is significant. We do not exclude insignificant factors and therefore also have to report their insignificance in Table 4.4. Notice, this does not mean that market opening presented by factors is weakly correlated with economic performance as typically the other factor is significant.

*Second*, the factors remain an aggregated measure of the market opening policies. If two or more (correlated) policies entering the same factor have opposing effects on economic performance the estimate of the aggregated factor will be around zero. Generally, the parameter estimate will be the average effect of all the policies, so even if the policies do not have opposing effects the estimate will be smaller, compared to focusing on the most important policies. Notice that for forecast purposes this is actually the correct value, but the test (falsely) concludes insignificance of the variable.

## 4.6. Singling out the more important factor

Having presented the forecasted impacts, the main objective of this chapter, we now proceed by trying to extract information on which market opening polices are more important for prices and productivity. Hence, this analysis complements the sectoral analyses in Part II of this report, where a final model estimated the relationship between individual Market Opening Milestones and price and productivity.

Below we report the identified Market Opening Milestones from sectoral analyses and compare them with the Market Opening Milestones entering the "driving factor" – whenever this can be identified – from the forecast analysis of this chapter. If it is the same milestones that appear in both estimations we may speculate whether these Market Opening Milestones are actually more important for market opening to affect prices productivity than others.

The general finding are that two analyses do not contradict each other when pointing to key Market Opening Milestones since in 15 out of 17 cases the milestones identified as more important in the sectoral analyses, enter the driving factors of the forecast analysis. For example, in the model for electricity price MOM2 is singled out in the sectoral analyses while factor 1 (F1) is singled out as the more important of the two factors in the forecasting analysis of this chapter, cf. Table 4.5. The key is that MOM2 enters F1. However, so do many other Market Opening Milestones making it virtually impossible to identify MOM2 as the single most important policy to implement when aiming at lower prices and higher productivity.

**Table 4.5: Significant Market Opening Milestones from identification and forecasting analysis**

| Sector | | Significant milestones identification | Driving latent factor | Market Opening Milestones in driving factor |
|---|---|---|---|---|
| Electricity | Price | MOM2 | F1 | MOM1-MOM2, MOM4-MOM5, MOM8-MOM9 |
| | Prod | MOM2, MOM9 | F2 | MOM3, MOM6-MOM7 |
| Telecom mobile | Price | MOI | F1 | MOM1-MOM4 |
| | Prod | MOM5 | F2 | MOM5 |
| Telecom all | Price | F1 | F1 | MOM1-MOM4 |
| | Prod | MOI | F1 | MOM1-MOM4 |
| Air transport | Price | MOI | F1 | MOM1-MOM7, MOM9, MOM10 |
| | Prod | MOI | F1, F2 | All |
| Rail passenger | Price | MOM8 | F1 | MOM1, MOM4, MOM6-MOM8 |
| | Prod | MOM7, MOM8 | F1 | MOM1, MOM4, MOM6-MOM8 |
| Rail freight | Price | MOM6 | F2 | MOM2-MOM3, MOM5 |
| | Prod | MOM6, MOM7 | F1, F2 | All |
| Urban | Price | MOM1 | F1, F2 | All |
| | Prod | MOI | F1, F2 | All |
| Gas | Price | MOM3, MOM7, MOM8 | F1, F2 | All |
| | Prod | - | - | - |
| Postal services | Price | F1, F2 | F1, F2 | All |
| | Prod | F2 | F2 | MOM1, MOM9-MOM12 |

Note: The table shows the MOMs singled out in the sectoral analyses as being more important for market opening to affect prices and productivity, the column Driving MOMs sectoral analyses. To find the driving factor in the forecast analysis of this chapter, we chose the factor that represented the largest impact on price and productivity. From factor analysis in the sectoral analyses Part II of this report, we know which MOMs entered the two factors – this is shown in the final column, MOMs in driving factor.
Source: Copenhagen Economics

Summing up, we generally conclude that the two analyses confirm each other, but more notably they jointly confirm the high degree of uncertainty attached to any attempt of identifying key policies. Often either analysis can simply not point to a selection of the full set of MOMs.

# Chapter 5 The economy-wide effects of market opening

This chapter describes how market opening in the network industries has affected the whole EU15 economy. The economy-wide effects of market opening have been calculated using the Copenhagen Economics Trade Model (CETM). The CETM model is a global, static, multi-regional general equilibrium model. The model represents state-of-the-art developments within models of services production and the analysis of regulatory barriers, market integration and price reforms. The current version of the CETM model has been adapted specifically to the analysis of the provision of network services in the EU15. This implies that the model explicitly includes seven network industries, 14 individual member states in the EU, and the sectors where reforms have a significant economy-wide impact (including goods-producing sectors). A description of the CETM model is provided in the last section of this chapter and further technical documentation is provided in Appendix F.

Below, the first section summarises the role of the network industries in an economy-wide context to give an understanding of their linkages to other parts of the economy. The economy-wide effects are then reported for the analysed scenarios.

## 5.1. The importance of the network industries in the EU economy

The seven network industries considered in the analysis (telecommunications, electricity, urban transport, rail transport, air transport, gas and postal services) constitute approximately 6 percent of total value added in the EU15 (in 2001, according to the GTAP6 database). The total share of the network industries in national economies is close to this EU-wide average for all member states.

Two network industries are considerably larger than the others; telecommunications and electricity, each accounting for 1.9 percent of total value added in the EU15. The other network industries all constitute less than 0.7 percent of total value added. Market opening in telecommunications and electricity is therefore relatively more important for explaining economy-wide effects. The share of all network industries in total value added is reported in Table 5.1 for the EU15 as a whole.

**Table 5.1: Share of network industries in total value added in the EU15**

| Sector | Share [percent of total value added] |
|---|---|
| Telecommunications | 1.9 % |
| Electricity | 1.9 % |
| Urban transport | 0.3 % |
| Rail transport | 0.2 % |
| Air transport | 0.7 % |
| Gas | 0.2 % |
| Postal services | 0.6 % |
| **Total** | **5.8 %** |

Note: The table shows value added in network industries as a percentage of total value added in the EU15 in 2001. Source: GTAP6 database.

The network industries tend to provide crucial infrastructure services that are necessary for both consumers and firms. Therefore, an important driver of economy-wide effects is the role of the network industries for other parts of the EU economy.

Table 5.2 shows that network services are primarily consumed by other service sectors. For example, the two sectors business services and ‘other services’ together account for 56 percent of telecom services in the EU. This implies that the service sectors can be expected to experience the strongest spill-over effects from market opening in the network industries. For a precise definition of the sectors included in the CETM model, please refer to Appendix E.

**Table 5.2: Sectoral shares of total EU15 consumption of network services by firms**

| | Business services | Distri-butive trade | Other services | Metal and electro-technical indu-stries | Petro-leum and chemical indu-stries | Re-maining sectors | Total |
|---|---|---|---|---|---|---|---|
| Tele-communications | 29 % | 16 % | 27 % | 7 % | 3 % | 18 % | **100 %** |
| Electri-city | 8 % | 12 % | 20 % | 19 % | 18 % | 23 % | **100 %** |
| Urban transport | 6 % | 22 % | 33 % | 11 % | 9 % | 19 % | **100 %** |
| Rail transport | 7 % | 24 % | 31 % | 11 % | 9 % | 18 % | **100 %** |
| Air transport | 12 % | 11 % | 40 % | 10 % | 6 % | 21 % | **100 %** |
| Gas | 16 % | 13 % | 27 % | 5 % | 9 % | 30 % | **100 %** |
| Postal services | 25 % | 14 % | 29 % | 8 % | 3 % | 21 % | **100 %** |

Note: The table demonstrates how consumption of network services by firms (as intermediate inputs) is distributed across sectors in the economy. For example, business services account for 29 percent of the total consumption of telecommunications by firms, while metal and electrotechnical industries account for only 7 percent. Total consumption of network services by firms includes both domestically produced and imported network services. ‘Other services’ includes e.g. construction services, recreational services and government services. ‘Remaining sectors’ includes e.g. the network industries, agriculture and extraction industries. See Appendix E for the corresponding sector mappings to NACE codes. Note that network services are also part of final demand, i.e. consumed by end-users.
Source: GTAP6 database.

To get a better understanding of how network services are used in the EU economy, it is also useful to consider the share of network services in total intermediate inputs in non-network industries. In sectors where network services are used relatively more intensively, the spill-over effects of market opening will be relatively more important. Table 5.3 illustrates the share of the two largest categories of network services (telecommunications and electricity) in total intermediate inputs for selected non-network industries. Again, there is a slight tendency for service sectors to be relatively more intensive users of network services (compared to industrial sectors).

**Table 5.3: Network services' share of intermediate inputs in selected non-network sectors**

| | Business services | Distri-butive trade | Other services | Metal and electro-technical industries | Petroleum and chemical industries | Average for all non-network sectors |
|---|---|---|---|---|---|---|
| **All network services** | **8 %** | **9 %** | **6 %** | **4 %** | **6 %** | **6 %** |
| Telecom-munications | 4 % | 3 % | 2 % | 1 % | 1 % | 2 % |
| Electricity | 2 % | 3 % | 2 % | 2 % | 4 % | 2 % |

Note: The table demonstrates that telecommunication services account for 4 percent of total intermediate inputs in business services, but only 1 percent of the intermediate inputs used in metal and electrotechnical industries. 'Other services' includes e.g. construction services, recreational services and government services. Among the non-network sectors not included in the table (extraction industries, food and agriculture, and 'rest of the economy') only extraction industries are significant users of network services (specifically electricity and transport services).

Source: GTAP6 database.

In summary, the role of the network industries in the EU economy points to two important facts. First, due to their large size relative to other network industries, telecommunications and electricity are the most important sectors in an economy-wide perspective. Second, due to their relatively larger and more intensive use of network services, the service sectors are likely to experience the strongest spill-over effects. These pieces of information will prove useful to intuitively understand the economy-wide effects of market opening in the network industries.

## 5.2. Evaluating the economic impacts in a broader context

Before we turn to the economy-wide effects of market opening, this section evaluates the size of the shock by comparing it to the overall economic development in the EU15 from 1990-2001 and other similar studies. The purpose is to assess whether the shock seem realistic.

We find that estimated shocks that enter the CETM are of a realistic magnitude when looking at the overall economic development from 1990-2001. Furthermore, they are of the same magnitude as previous studies assessing the link between market opening and performance.

First, we look at how the shocks are expected to influence the overall simulation outcomes. We do that by comparing the economic size of the sectors with the respective shocks. Sectors that constitute a large part of the economy and are subject to significant shocks will naturally have important influences on the overall economic outcome. Conversely, small sectors with small and sometimes counterintuitive impacts will not produce large economic effects. The full comparison is illustrated in Table 5.4.

**Table 5.4: Expected sector influence on overall results**

| | | | |
|---|---|---|---|
| Large share | | Electricity | Telecommunications |
| Medium share | | Air | Postal |
| Small share | Urban, Rail pass. | Gas | Rail freight |
| | Small shock | Medium shock | Large shock |

Note: Share refers to the share of the economy. Large share reflects a share larger than 1%, medium 0.5-1% and small is given by a share smaller than 0.5%. All shares are taken from Table 5.1. Shocks refer to a combination of price and productivity impacts. Small shocks are given by small shocks in both AND counterintuitive in at least one of the two measured impacts. Medium shocks lie between 0-10% in both, and large shocks above 10%. Notice, that postal services have a large impact in productivity, but a small counterintuitive in price, but due to the size of the productivity shock (28%) we classify the aggregate shock as large.

The table shows that telecommunications is expected to be a main driver of the economic simulations, followed by electricity, postal services and rail freight. Telecommunication services have a share of 1.9% and price and productivity impacts of more than 20%. On the other hand, urban, rail passenger and gas is not expected to contribute much, whereas air transport should have a medium impact. Since postal services also produces counterintuitive impacts for prices, we will leave that sector and focus exclusively on telecommunications and electricity below, when we do some “back-of-the-envelope” calculations.

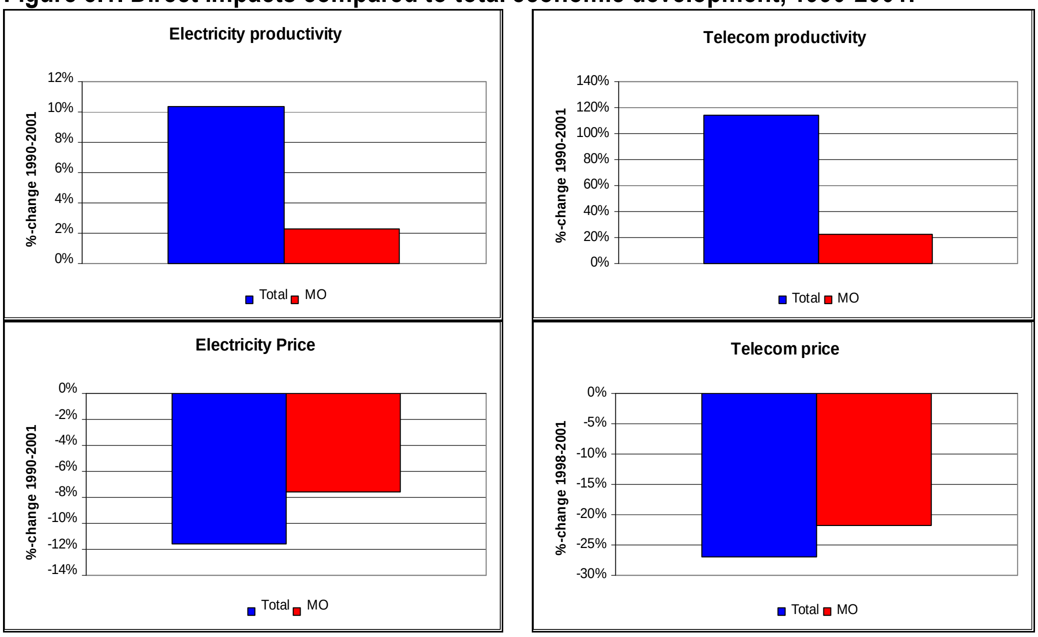
More specifically, productivity in telecommunications and electricity has risen by 23 and 2 percent, respectively (see Figure 5.1); and their share in value added in EU15 is 1.9 percent for both (see Table 5.1). Multiplying these values, we find that market opening has, *without including price effects and spill-over effects,* contributed to total value added in EU value by almost 0.48 percent[29].

. Direct  presents the direct impacts entered in the CETM for the EU15 compared to the total change in productivity and prices over the period 1990-2001 for the two most important network industries, telecommunications and electricity.

The figure shows that the price falls induced by market opening comprise a considerable part of the total price falls in both telecommunications and prices, whereas market opening has only contributed marginally to the total productivity change.

The high contribution to prices from market opening may reflect that market opening leads to fiercer competition which reduces the economic rents earned in the formerly regulated markets. The small contribution from market opening to productivity growth reflects that most changes in productivity in especially telecommunications, arises from technological developments[30]. For example, the strong productivity growth of the 1990s is often explained by the implementation of a vast array of technological inventions, and this is especially the case for some network industries.

**Figure 5.1. Direct impacts compared to total economic development, 1990-2001.**




[29] 23x0.019 + 2x0.019 = 0.48 percent.

[30] One could argue that market opening has been a driver of parts of technological developments. However, technological developments originating from Asia og North America are most likely not influenced by market opening in EU.

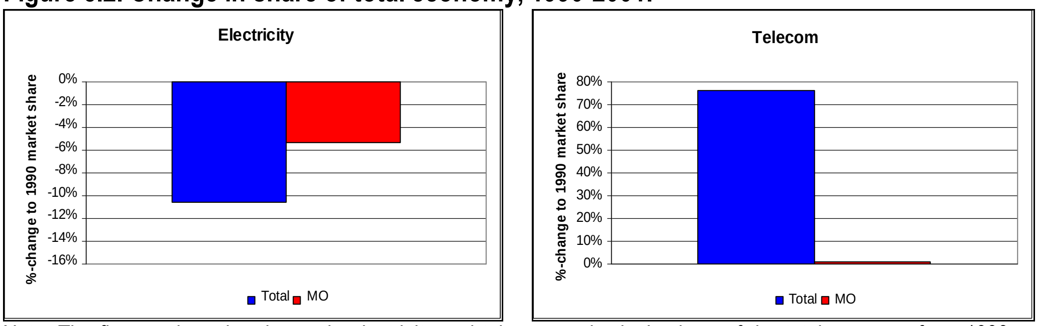
Note: The figures show the total change in productivity and prices in electricity and telecommunication from 1990-2001 and the share out of that, that can be attributed to market opening.
Source: Copenhagen Economics.

The figure shows that the productivity growth in telecommunications amounted to 114% over the period of which only 22% points are predicted by market opening. This is a minor, but still non-trivial effect. Though having experienced much lower overall productivity growth the same picture emerges for electricity. In contrast, the predicted price fall of -22% in telecommunications comprise a relative large part of the total fall of 27% in telecommunications and again a similar picture emerges for electricity (8% out of 12%).

The price and productivity shocks affect the share of telecommunications and electricity in the total economy. The change in this share between 1990 and 2001 is presented in Figure 5.2 (labelled "total") along side how much of this change is a result of market opening (labelled "MO").

For telecommunications, the productivity rise and price fall due to market opening balances each other out, with the consequence that market opening has contributed only marginally to the higher share of telecommunications out of the total economy in 2001 compared to 1990. For electricity, where the fall in prices due to market opening is much stronger than the productivity increase, the predicted change in the share is correspondingly larger.

**Figure 5.2. Change in share of total economy, 1990-2001.**




Note: The figures show the change in electricity and telecommunication's share of the total economy from 1990-2001 and how big a change that can be attributed to market opening.
Source: Copenhagen Economics.

Other studies have also tried to assess the potential of market opening in (some) network industries. These studies also found a link between market opening and prices with the size of the impact fairly close to that obtained in this study. In particular, Doove et al (2001) summarise, compare and extend a number of similar studies and find a link for all considered sectors: air, passenger transport, telecommunications and electricity supply. Using a cross-country regression Doove et al (2001) find a possible reduction of 31% in telecommunications prices if the 1997-level of barriers was completely removed, so that markets were fully opened.[31] Analogous the hypothesized fall in electricity prices would amount to 11%.

Transforming these figures to account for the *actual* development in market opening over the period 1997-2001, the implied reduction in telecommunication prices is 14% and 5% for electricity. This study suggests a reduction of 22% and 8% over the period 1990-2001 for telecommunications and electricity, respectively. Considering the difference in time periods the estimated impacts are very similar.

31 Doove et al (2001) perform the analysis on the basis of 24 OECD countries. However, all figures are given for EU countries included in the analyses, which were around 12.

## 5.3. Short-run effects of market opening

The model analysis demonstrates that market opening in the network industries has contributed significantly to the economic performance of the EU15 economy[32]. The simulations show that the accumulated price and productivity effects accruing from market opening until 2001 result in a 1.9 percent increase in welfare in the EU15. This corresponds to a yearly gain of approximately €98 billion in monetary terms. Furthermore, the effect on the labour market corresponds to a net addition of approximately 500 000 new jobs across the EU15, both inside and outside the network industries.

The economy-wide effects for the EU15 as a whole are presented in Table 5.5. Detailed results at the Member State level are presented in Appendix G. When interpreting the results, it is important to note that market opening has actually already taken place and that many effects have already emerged (the analysis is essentially an ex-post assessment)[33].

**Table 5.5: Economy-wide effects of market opening for the EU15**

| | Effects accruing from market opening 1990-2001 (short-run effects) | |
|---|---|---|
| | % change | Absolute effect |
| Welfare | 1.9 | € 98 bn |
| Value added | 2.0 | € 150 bn |
| Employment | 0.3 | 500 000 jobs |

Note: The table shows the economy-wide effects that emerge when the economy has adjusted fully to the effects of market opening. Welfare is measured as comprehensive consumption.
Source: CETM model - Copenhagen Economics.

The distribution of the welfare effects reveals large differences across member states. Member states with a high degree of market opening (e.g. Denmark and Finland) experience significantly larger gains than member states with less market opening (e.g. Greece), as shown in Table 5.6, which includes changes in both welfare and market opening.

[32] The model incorporates the 10 new member states together with the rest of the world. Including them individually will not markedly impact the EU15 member states, and market opening in the EU15 will, likewise, not markedly impact the new member states. Only market opening within the new member states will have a significant economic impact. However, since market opening has not been analysed in the new member states, no market opening milestones (MOM) or market opening index (MOI) exist. Consequently, it is not feasible to calculate the economy wide effects of market opening in the new member states.

[33] The effects are therefore calculated as changes compared to what the EU economy would look like without market opening. For example, when the effects of market opening are fully realised, there will be 500 000 more jobs in the EU economy than if market opening had not taken place (though many of these new jobs have already been created).

**Table 5.6: Distribution of welfare effects across member states**

| | Welfare | | Benchmark value added | Market Opening Index (MOI) | |
|---|---|---|---|---|---|
| | | | | Point change 1990-2000 | |
| **Member State** | % change | Absolute effect | 2001 | Telecom | Electricity |
| **EU15** | **1.9** | **€ 98 bn** | **€ 7690 bn** | **47** | **25** |
| Austria | 2.3 | € 3 bn | € 177 bn | 55 | 00 |
| Belgium and Luxembourg | 1.5 | € 3 bn | € 247 bn | 49 | 22 |
| Denmark | 4.9 | € 4 bn | € 153 bn | 85 | 45 |
| Finland | 6.5 | € 4 bn | € 115 bn | 50 | 66 |
| France | 1.4 | € 10 bn | € 1241 bn | 39 | 15 |
| Germany | 2.2 | € 26 bn | € 1776 bn | 58 | 40 |
| Greece | 0.4 | € 0 bn | € 122 bn | 16 | 00 |
| Ireland | 2.2 | € 1 bn | € 104 bn | 37 | 16 |
| Italy | 1.4 | € 10 bn | € 1048 bn | 62 | 02 |
| Netherlands | 3.3 | € 7 bn | € 357 bn | 69 | 20 |
| Portugal | 1.6 | € 1 bn | € 105 bn | 47 | 06 |
| Spain | 1.4 | € 6 bn | € 597 bn | 43 | 14 |
| Sweden | 5.9 | € 7 bn | € 204 bn | 49 | 63 |
| United Kingdom | 1.4 | € 17 bn | € 1443 bn | 30 | 29 |

Note: Welfare is measured as comprehensive consumption. The change in the Market Opening Index from 1990 to 2000 is presented because it affects prices and productivity in the network industries until 2001.
Source: CETM model – Copenhagen Economics, Copenhagen Economics (2004) and GTAP6 database.

The economy-wide gains are explained by both the direct effects of market opening in the network industries (as described by the econometric estimates) and the spill-over effects on other sectors of the economy. The effects of market opening on the prices of network services are a main driver of the spill-over effects on other sectors. Table 5.7 presents the aggregate effects of market opening on the prices of network services. These price effects include the direct effects of market opening on both prices and productivity, as well as indirect spill-over effects and changes in e.g. labour costs.

**Table 5.7: Aggregate effects of market opening on the provision of network services**

| | Telecom munica-tions | Electri-city | Urban trans-port | Rail trans-port | Air trans-port | Gas | Postal services |
|---|---|---|---|---|---|---|---|
| Prices | -24 % | -7 % | 0 % | -27 % | -6 % | 0 % | -12 % |
| Market size | 6 % | 3 % | 3 % | 4 % | 9 % | 3 % | 6 % |

Note: The table shows average EU15 changes in prices and market size in network industries as a result of market opening. Market size is measured as the total value of output.
Source: CETM model – Copenhagen Economics.

Demand for network services increases significantly (measured as the volume of services provided), but the price drops mean that the overall market sizes (measured as the total value of output) show only modest growth. The lower prices of network services (except in the case of gas and urban transport) serve as a strong stimulus for other sectors of the economy. The small share of urban transport in the EU economy means that the negative impact of market opening in urban transport in some member states has a negligible economy-wide impact.

The spill-over effects across non-network industries are evenly distributed for the EU as a whole. As expected, however, the spill-over effects tend to be slightly stronger for the service sectors as a result of their more intensive use of network services. Table 5.8 below presents spill-over effects on the most important non-network sectors. Detailed results for all sectors are provided in Appendix G.

**Table 5.8: Spill-over effects on key non-network sectors (EU15 averages)**

| | Business services | Distributive trade | Other services | Metal and electro-technical industries | Petroleum and chemical industries |
|---|---|---|---|---|---|
| Market size | 2 % | 2 % | 1 % | 1 % | 2 % |
| Value added | 2 % | 2 % | 1 % | 0 % | 1 % |
| Employment | 1 % | 0 % | 0 % | -1 % | 0 % |

Note: The table shows average EU15 changes in market size, value added and employment in select non-network industries as a result of market opening. Market size is measured as the total value of output. Detailed results for all sectors are provided in Appendix G.
Source: CETM model – Copenhagen Economics.

The economic stimulus provided by market opening increases economic activity across the EU. This contributes to increased economic welfare, but at an environmental cost. The increased activity in the EU economy implies higher $CO_2$ emissions due to higher use of energy and fossil fuels. In total the calculations show that total $CO_2$ emissions in the EU15 increase by approximately 4 percent for the EU15 as a result of market opening. In absolute terms, the higher emission levels are concentrated to the electricity sector and petroleum and chemical industries. Changes in emissions (from fossil fuels) from other sectors are negligible. Results at the Member State level are provided in Appendix G.

It is, however, important to note that the calculations isolate only the direct effects of market opening. The effects of other changes, related or unrelated to market opening, in e.g. environmental policies and technologies are not considered.

## 5.4. Sensitivity analysis

The results from the model simulations are dependent on a number of parameters regarding modelling assumptions, the underlying data and the precision of the calculated policy shocks. The purpose of the sensitivity analysis is to determine how changes in strategic parameters influence the calculations. The sensitivity of the results to modelling assumptions and policy impacts has been analysed using both piecemeal and systematic sensitivity analysis. The piecemeal sensitivity analysis allows only one parameter to change at a time. The systematic sensitivity analysis allows a range of parameters to change simultaneously within specified ranges. The model is used to simulate the same scenario many times, and each time the model randomly chooses a new configuration of the selected parameters.

*Piecemeal sensitivity analysis*

The piecemeal sensitivity analysis focuses on the two most important elasticities with regard to the welfare and employment effects; the elasticity of substitution between individual service varieties and the elasticity of labour supply. The results show small and predictable impacts of changing these elasticities. Gains are slightly higher if individual service varieties are worse substitutes than assumed, because distortions (e.g. mark-ups over costs) then become more important. Conversely, gains are slightly lower if individual service varieties are better substitutes than assumed. The elasticity of labour supply has a noticeable effect on employment, but little influence on the welfare effects.

The piecemeal sensitivity analysis also includes the size of the policy shocks by considering a case where the price and productivity effects for telecommunication and electricity are set to their lower bounds (according to econometric results). The resulting effects are of the expected magnitude, i.e. approximately 20 percent lower gains (the econometric estimations found lower bounds for telecommunication and electricity that were 20-30% below the central estimates).

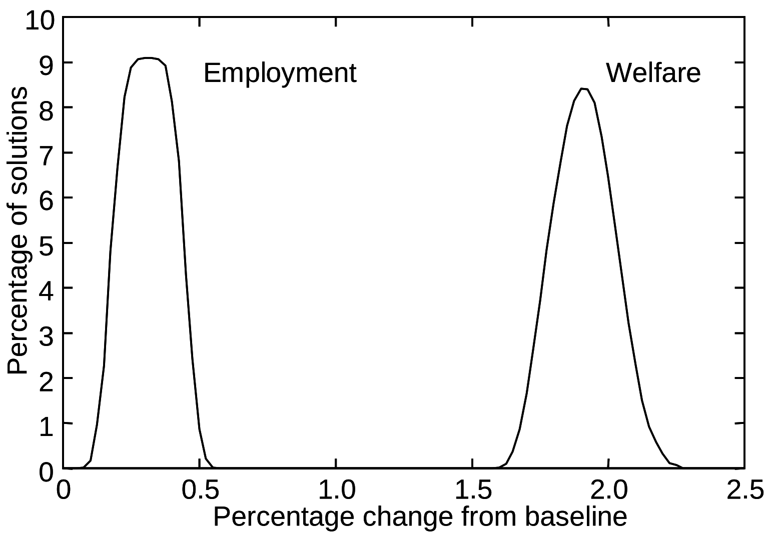
**Table 5.9: Piecemeal sensitivity analysis**

| | | Economy-wide impacts | | |
|---|---|---|---|---|
| | **Value** | **Welfare** | **Value added** | **Employment** |
| Benchmark | | 1.9 | 2.0 | 0.3 |
| **Model assumptions** | | | | |
| Elasticity of substitution between individual service varieties | 4 | 2.3 | 2.2 | 0.4 |
| | 6 | 1.7 | 1.9 | 0.3 |
| Elasticity of labour supply | 0.1 | 1.9 | 1.9 | 0.1 |
| | 0.3 | 1.9 | 2.1 | 0.5 |
| **Policy shocks** | | | | |
| Lower bounds | - | 1.7 | 1.8 | 0.3 |

Note: The benchmark effects reflect the short-run scenario of market opening until 2001. Welfare is measured as comprehensive consumption. Lower bounds for policy shocks have been applied to telecommunication (price and productivity) and electricity (productivity). The econometrics did not reveal other bounds.
Source: CETM model - Copenhagen Economics.

*Systematic sensitivity analysis*
In the systematic sensitivity analysis, the short-run scenario (of market opening until 2001) has been simulated 500 times with different configurations of the parameters in Table 5.9. Again, the analysis indicates that the results are satisfyingly robust to changes in strategic parameters. Figure 5.3 shows that both the welfare and employment outcomes are distributed across relatively narrow intervals.

**Figure 5.3: Distribution of welfare and employment effects**




Note: The graph shows aggregate welfare and employment effects for the EU15.
Source: CETM model – Copenhagen Economics.

Table 5.10 shows the parameters and distributions used in the systematic sensitivity analysis. Note that the systematic sensitivity analysis only includes model assumptions and disaggregation data.

**Table 5.10: Parameters and distributions in the systematic sensitivity analysis**

| | Analysed range | | Distribution |
|---|---|---|---|
| | Lower bound | Upper bound | |
| **Model assumptions** | | | |
| Elasticity of substitution in value added | 0.75 | 1.25 | Normal |
| Elasticity of substitution between individual service varieties | 4 | 6 | Normal |
| Elasticity of labour supply | 0.1 | 0.3 | Normal |
| **Disaggregation data** | | | |
| Labour share in the disaggregated postal services sector | - 10 % from data | + 10 % from data | Normal |

Note: The econometric estimations did not reveal any systematic bias for the price effects in electricity.
Source: Copenhagen Economics.

## 5.5. Long-run effects of market opening

The results reported in the previous sections only consider the economy-wide effects of market opening on prices and productivity in the period 1990-2001. The econometric estimations of the long-run effects on prices and productivity beyond 2001 are unfortunately significantly less reliable than the short-run estimates. The simulations of the economy-wide effects in the long-run necessarily reflect the uncertainty embedded in the econometric estimations.

The large uncertainty regarding the long-run effects means that no reliable conclusions can be drawn regarding the economy-wide effects of market opening. The econometric estimations did not produce central estimates for the long-run price and productivity effects, only potential lower and upper bounds. Especially the upper bounds are rather extreme and give rise to accordingly extreme results in the economy-wide simulations. The long-run effects presented in Table 5.11 should therefore not be taken literally, but only serve to illustrate the large uncertainty that exists regarding the long-run impacts of market opening.

**Table 5.11: Long-run economy-wide effects of market opening for the EU15**

| | Long-run effects of market opening | |
|---|---|---|
| | Lower bound | Upper bound |
| Welfare | 3.7 % | 9 % |
| Value added | 4.1 % | 13 % |
| Employment | 0.5 % | 1 % |

Note: The table shows the economy-wide effects that emerge when the economy has adjusted fully to the long-run effects of market opening. Welfare is measured as comprehensive consumption.
Source: CETM model - Copenhagen Economics.

## 5.6. The Copenhagen Economics Trade Model

The Copenhagen Economics Trade Model (CETM) is a global, static, multi-regional general equilibrium model. The model represents state-of-the-art developments within models of services production and it has been specifically designed for the analysis of network industries, price reforms, market integration and regulatory barriers to services trade and foreign direct investment (FDI).

The model draws on the GTAP database (version 6) which provides internally consistent data on production, consumption and international trade by country and sector for the global economy in 2001. Importantly, the database combines both inter-sectoral linkages within regions and bilateral trade data characterizing economic linkages between regions. The version 6 of the database is the newest global database available of this kind. A detailed description of the GTAP6 database is provided in Dimaranan and McDougall (2005).

The current version of the CETM model has been adapted specifically to the analysis of the provision of network services in the EU15. This implies that the model explicitly includes seven network industries, 14 individual member states in the EU[34], and the sectors where reforms have a significant economy-wide impact (including goods-producing sectors). The detailed sectoral disaggregation in the model allows for a detailed analysis of the spill-over effects from individual network industries to sectors elsewhere in the EU economy.

The model also incorporates the rest of the world, but does so in a more stylized manner to ensure both transparency and tractability of the model. Table 5.12 provides an overview of the regions and sectors represented in the model.

**Table 5.12: Regions and sectors in the Copenhagen Economics Trade Model**

| Regions | Sectors |
|---|---|
| 1. Austria | Network industries: |
| 2. Belgium and Luxembourg | 1. Telecommunication |
| 3. Denmark | 2. Electricity |
| 4. Finland | 3. Gas |
| 5. France | 4. Rail transport |
| 6. Germany | 5. Urban transport |
| 7. Greece | 6. Air transport |
| 8. Ireland | 7. Postal services |
| 9. Italy | |
| 10. Netherlands | Other service sectors: |
| 11. Portugal | 8. Business and financial services |
| 12. Spain | 9. Distributive trade |
| 13. Sweden | 10. Other services |
| 14. United Kingdom | |
| 15. Rest of the World | Goods-producing sectors: |
| | 11. Metal- and electrotechnical industries |
| | 12. Petroleum and chemical industries |
| | 13. Extraction industries |
| | 14. Food and agriculture |
| | 15. Other industries |

Source: Copenhagen Economics.

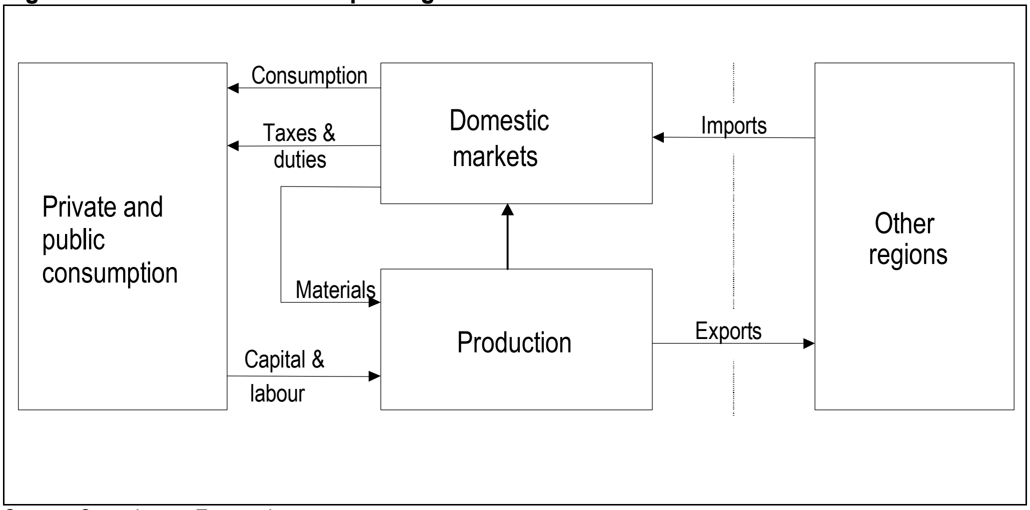
Services production takes place within 7 network industries and 3 other services sectors. All other production, mainly industrial production of goods, is captured by 5 additional sectors.

[34] The large level of disaggregation can lead to numerical problems due to the limited size of certain sectors in small member states. It was therefore not possible to include Luxembourg as a separate region. Instead, Belgium and Luxembourg have been aggregated to a single region.

Compared to more traditional analyses, the model contains a relatively large number of sectors. This is required for the detailed analysis of spill-over effects across sectors, but does imply that the sector results must be carefully interpreted (especially given the quality of services statistics).

Each of the regions has a representative consumer, a government and a production sector for each of the goods and services. Figure 5.4 gives an overview of the markets, the agents and the flows of goods, services and factors in the model. Firms producing goods and services represent the supply side of the model. All goods and services are being produced with materials and primary factors capital and labour. A representative agent represents final demand and it finances its consumption with income from sales of capital and labour. Finally, a government provides public goods financed through taxes and duties.

**Figure 5.4: Overview of the Copenhagen Economics Trade Model**




Source: Copenhagen Economics.

*Modelling of the supply and demand for services*

The modelling of services in the CETM model builds specifically on Markusen, Rutherford and Tarr (2000) and Jensen, Rutherford and Tarr (2003). The model distinguishes between two categories of firms producing services. One category, represented by "other" services (sector 10 in Table 5.12), produces services under constant returns to scale and the firms sell their output in perfectly competitive markets. The other category, covering all other services, produces services under increasing returns to scale and the firms sell their output in markets characterised by imperfect competition.

In the case of imperfectly competitive firms, the model incorporates production of services in a country by both purely national firms and by foreign firms. Foreign firms represent subsidiaries of multinational firms that sell services abroad via FDI in local production corresponding to "commercial presence" (mode 3) in the World Trade Organisation (WTO) classification. The key difference between national firms and foreign firms is in the use of the primary factors labour and capital. National firms only use domestic labour and capital, whereas the production in foreign firms also uses a specialized intermediate good provided by their parent company. This good can be thought of as knowledge capital embodied in capital provided by FDI. The term knowledge capital will hereafter be used when referring to this specialised input.

Users of services include firms, governments and households. They purchase a bundle of services and their benefit from services depends on the number of varieties available. Individual varieties of services are available in the sectors with services production under increasing returns to scale. Recent literature (see e.g. Broda and Weinstein, 2004) has shown that growth in product varieties is an important source of gains from trade. The more varieties, the lower the costs of a quality adjusted unit of services. That is, an additional variety of a given service not only represents a value in itself, but also makes other services more valuable and productive. The model also captures that firms use services as intermediate inputs and that lower costs of inputs decrease the prices of services. Thus, lower prices of services benefit not only the firms purchasing the services but also firms, government and households purchasing their output. The model therefore captures the economy-wide effects of reforms in the network industries.

Users of services not only distinguish between individual varieties of services, they also distinguish services according to nationality. For example, French customers view services provided by French firms as better substitutes for each other than services provided by, say, the French subsidiary of a German multinational. Also, services provided locally, whether by a purely national firm or by a foreign firm, are better substitutes for each other than services provided across borders ("cross-border supply" (mode 1) in the WTO classification).

*Modelling of regulatory reforms*
The model represents the direct impacts of market opening using two types of economic shocks; price shocks and productivity shocks. Price shocks are implemented by exogenously adjusting the price wedge between producer prices and producer costs. The modelling of lower prices is implemented in two steps. First, existing production data is reinterpreted to incorporate mark-ups (over true costs) charged by firms. Second, in the simulations, these mark-ups are reduced to achieve the required price shock. If the price shocks imply higher prices, no reinterpretation of data is necessary. The simulations then only introduce new mark-ups over costs to achieve the required price shock.

Productivity shocks are implemented by exogenously adjusting the use of real resources. A positive productivity shock means that more output can be produced with the same amount of inputs (or the same output can be produced with smaller amounts of inputs). Depending on the characteristics of each network industry, productivity shocks are implemented for respectively labour and capital following the econometric estimates.

The estimated sectoral price and productivity shocks determine the size and composition of the impacts of market opening in the network industries. The exact methodology for translating the sectoral shocks to the model is presented in chapter 4. Since the econometrics allows for calculations of the accumulated price and productivity effects of market opening for individual years, it is possible to create a direct correspondence between market opening, the defined policy scenarios and the shocks introduced in the model.

*Modifications for the modelling of network industries*
The study of Market Opening in Network Industries (Copenhagen Economics, 2004) covers market opening in seven network industries (i.e. electricity, gas, urban transport, rail transport, air transport, telecommunication and postal services). This corresponds to a more detailed level of sectoral representation than the original GTAP6 database. The CETM model database includes two specific improvements on the GTAP6 database. First, the communication sector in GTAP has been disaggregated to a telecommunications sector and a postal services sector. Second, the transport sector in GTAP has been disaggregated into urban transport, rail transport and other transport activities.

The communication sector in GTAP6 corresponds to the NACE sector I.64 (post and telecommunications). The sector is made up of only postal services and telecommunications, i.e. the sector contains no unspecified activities. The basis for the disaggregation is revenue data for the respective sub-sectors. Table 5.13 illustrates the revenue figures for the EU15 as a whole. Where data allows, the actual disaggregation is based on national data.

**Table 5.13: Disaggregation of the communications sector**

| Sector (NACE Rev.1.1 classification) | Total revenues (2001, € bn) | Share of total revenues (2001) |
|---|---|---|
| I.64. Post and telecommunications | 329,5 | 100 % |
| 64.10 Post and courier activities | 86,5 | 26 % |
| 64.20 Telecommunications | 243,0 | 74 % |

Note: The figure for post and courier activities covers the EU25. The actual disaggregation uses national data.
Source: Performance database and WIK (2004).

To achieve a proper representation of the telecommunication sector, the disaggregation recognises that the aggregated communication sector largely reflects the structure of the telecommunication sector (due to the large weight of telecommunications relative to postal services). The structure of the disaggregated telecommunication sector is therefore calibrated to be symmetrical to the aggregated communication sector.

The disaggregation also recognises that postal services are labour intensive rather than capital intensive. The capital and labour shares of the disaggregated postal sector are therefore adjusted to match the detailed sectoral data provided in NERA (2004). Where data is available, the adjustments are based on national data. The sensitivity of the results to uncertainty regarding the sectoral structure is, furthermore, included in the systematic sensitivity analysis[35].

The ‘other transport’ sector in GTAP6 is an aggregate of the NACE sectors 60 and 63 (see Table 5.14). The sector is largely made up of residual transport activities, i.e. the sector is a sink for many unspecified transport activities that are not explicitly represented in the GTAP database. This means that the sector cannot be disaggregated into only rail transport and urban transport. Instead, the transport sector is disaggregated into three sectors; rail transport, urban transport and other land transport (primarily freight transport by road).

**Table 5.14: Contents of the 'other transport' sector in GTAP**

| Sector (NACE Rev.1.1 classification) |
|---|
| 60. Land transport; transport via pipelines |
| 63. Supporting and auxiliary transport activities; activities of travel agencies |

Source: NACE Rev.1.1 definition and GTAP documentation.

The basis for the disaggregation is revenue data for the rail and urban transport sectors from the performance database reported in Copenhagen Economics (2004). The residual ‘other land transport’ sector corresponds to the difference between total revenues according to GTAP6 and the sum of urban and rail transport according to the performance database.

[35] Note that the sector “Post and courier activities” (NACE 64.10) is made up of two sub-sectors; national post activities (NACE 64.11) and other courier activities (NACE 64.12). The postal services sector is therefore broadly defined to include both public and private providers of all types of postal services. A more detailed disaggregation of the postal sector is not possible because of the lack of detailed and consistent statistics (statistical categories in the postal sectors are marred by ambiguities and overlapping concepts, see WIK, 2004). For example, major providers operate in both market segments according to the NACE classification. In addition, USPs are acquiring more and more private express service providers. A more detailed disaggregation would therefore in effect correspond to a disaggregation of individual companies (primarily USPs). Therefore, to keep the analysis transparent and tractable, further disaggregation of the postal sector has not been performed. The consequence is that the effects for the postal sector will be slightly overestimated. To get a sense of the potential bias, WIK (2004) estimated that letter post (the most important share of the sector that is being exposed to competition by market opening) accounts for about 59 percent of total postal sector revenues. USPs also account for about 47 percent of revenues from courier activities (express and parcel markets), but a considerable share of those activities were highly competitive before market opening occurred. The exact extent to which the effects on the postal sector are overestimated can therefore not be determined exactly, but is sufficiently small not to influence the economy-wide effects of market opening.

Table 5.15 illustrates the revenue figures for the EU15 as a whole. Where data allows, the actual disaggregation is based on national data. Due to lack of detailed statistics on the production and economy-wide use of transport services, the disaggregated sectors are assumed to have identical cost and revenue structures.

**Table 5.15. Disaggregation of the transport sector**

| Sector (CETM model classification) | Total revenues (2001, € bn) | Share of total revenues (2001) |
|---|---|---|
| Transport | 586 | 100 % |
| Urban transport | 57 | 10 % |
| Rail transport | 36 | 6 % |
| Other land transport | 493 | 84 % |

Note: The table shows aggregate numbers for the EU15. The figure for other land transport is a residual.
Source: Performance database and the GTAP6 database.

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