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A world CGE model with multinational firms: MIRAGE MNF version

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Table of Contents

SUMMARY

In his pioneering work (1997), Petri mentioned three broad reasons for incorporating FDI in CGE analysis. First, FDI has become an important and dynamic feature of the world economy. Second, FDI liberalization is more and more an issue of bilateral and multilateral discussion. Finally, CGE model based on actual trade and FDI can help to understand why trade and investments are complements in some circumstances and substitutes in others. It is also essential to better model multinational firms which account for a significant share of FDI and more than two-thirds of world trade according to UNCTAD (1996) in order to better understand interactions between FDI and trade.

This study presents an original modeling of FDI in the world CGE model developed at CEPII nicknamed MIRAGE. Our modeling builds on a worldwide FDI database matching the MIRAGE nomenclature namely in three dimensions (sector, source, destination) also developed at CEPII. On the supply side, production is differentiated according to origins of capital. This enables us to distinguish production made by affiliates of multinationals from production made by local firms. On the demand side, we adopt a different demand structure between industrial goods and services. We follow Petri's approach (1997) for industrial goods which are first differentiated by their origin of capital and then by their production location. The order of choice is inverted for services since services produced abroad are considered less substitutable with services produced locally (Lee and Van der Mensbrugghe (2001)).

This new modeling – MIRAGE MNF version – is first compared to the version of the model with cross-border investment where multinational firms are not explicitly modeled – MIRAGE Portfolio version. We then compare simulations results of a corporate tax exemption on foreign capital in France and Belgium. For these simulations the elasticity of investment to capital return in the model was chosen to be consistent with empirical estimates of the elasticity of FDI to corporate taxation. A corporate tax exemption on foreign capital appears to be positive in France but negative in Belgium, especially in services where the majority of capital is foreign-owned.

RESUME COURT

Cette étude présente une nouvelle modélisation de l'investissement direct étranger (IDE) dans le modèle MIRAGE. Elle s'appuie sur une base mondiale d'IDE correspondant à la nomenclature du modèle (secteur, origine, destination) développée au CEPII (Boumellassa, Gouel et Laborde (2007)). La prise en compte de l'origine du capital nous a permis de distinguer la production des filiales de multinationales de celle des entreprises locales. Une nouvelle structure de la demande différente entre les secteurs industriels et les services est également adoptée. Les biens industriels sont d'abord différenciés par leur origine du capital puis par leur lieu de production suivant l'approche de Petri (1997). Le choix s'effectue dans l'ordre inverse pour les services car les services produits à l'étranger sont en général moins substituables avec ceux produits localement (Lee et Van der Mensbrugghe (2001)).

Cette nouvelle modélisation – MIRAGE MNF – est d'abord comparée une version du modèle avec investissements transfrontaliers dans laquelle les multinationales ne sont pas modélisées explicitement – MIRAGE Portefeuille. Nous simulons ensuite une exemption d'impôt sur les sociétés pour les entreprises étrangères en France et en Belgique. Pour ces simulations, l'élasticité de l'investissement au rendement du capital a été calibrée de façon cohérente avec les estimations empiriques de l'élasticité de l'IDE à l'impôt sur les sociétés.

1. Introduction

After double-digit growth rates in 2006 and 2007, inward FDI stock decreased by 4.8% in 2008 according to UNCTAD (2009). In the *World Investment Survey 2009*, UNCTAD expects FDI flows to approach an estimated $1.8 trillion in 2011 – almost the same as in 2008. Despite the fact that FDI has grown more rapidly than world trade over the past three decades, most applied trade models do not explicitly model FDI. It is largely due to the fact that a worldwide FDI database matching the nomenclature of CGE models, namely in three dimensions (sector, source, destination), was until recently not available. It can also been explained by the fact that the introduction of multinational firms (MNF) has posed an important challenge to trade models for a long time (Markusen (2002)).

In his pioneering work (1997), Petri mentioned three main reasons for incorporating FDI in CGE analysis. First, FDI has become an important and dynamic feature of the world economy. Second, FDI liberalization is more and more an issue of bilateral and multilateral discussion. Finally, CGE models based on actual trade and FDI can help to understand why trade and investments are complements in some circumstances and substitutes in others. Furthermore, according to UNCTAD (1996), MNFs are responsible for an estimated two-thirds of world trade. This is another motivation to model production made by affiliates of multinationals as distinct from production made by local firms in a model designed for trade policy analysis, like the MIRAGE model used in this paper.

In this paper …

2. Model and data

2.1. The MIRAGE model and data

2.2. FDI database

A harmonized database of FDI stocks and flows matching the nomenclature of a world CGE model, namely in three dimensions (sector, source and destination), was until recently not available. Such a worldwide sectoral database was developed at CEPII by Boumelassa, Gouel and Laborde (2007). This database is used in this study to enable an original modeling of FDI in the multi-country, multi-sector CGE model MIRAGE. Various raw data were used to obtain this database: data from international organizations – IMF (1 dimension), OECD (2 dimensions), Eurostat (3 dimensions) – as well as national sources – WIIW (Vienna Institute for International Economic Studies) for example for Eastern Europe. Building a worldwide FDI database in 3 dimensions raises two main difficulties. First, a lot of values are missing and need to be estimated. Second, different raw data are often inconsistent between themselves. The authors consequently adopted a twofold methodology. They estimated missing values from the only 3-dimensional data available, the Eurostat data. Although Eurostat provides a good coverage of European FDI, some values are nevertheless missing – for confidentiality reasons notably. Missing FDI values were estimated using a gravity equation, while controlling for various variables: source and destination GDPs, GDPs per capita, geographic distance and cultural distance indicators (common language, colonial link). At this step, total inward and outward FDI per country did not match with other sources (IMF, OECD, national sources). A quadratic method was then used to balance the dataset in order to respect different constraints at 1 and 2 dimensions. In case of inconsistency between raw data, different weightings were attributed to the constraints as a function of the reliability of the sources in order to be closer to the most reliable sources. This methodology also enables one to easily incorporate more precise data (for instance national sources) at a later stage to reallocate a block of the database based on updated coefficients. To be used in MIRAGE, this database was converted from a sectoral Eurostat nomenclature (37 sectors) to the sectoral GTAP nomenclature (57 sectors). When a Eurostat sector was divided between several GTAP sectors, FDI flows and stocks were split in proportion of capital revenues data from GTAP. A balanced 113 regions x 113 regions x 57 sectors FDI database in flows and stocks matching MIRAGE nomenclature was thus obtained.

3. FDI modeling in CGE models

Relatively few models explicitly model FDI in a CGE framework (see Lejour and Rojas-Romagosa (2006) and Latorre (2009) for literature reviews). It can be mainly explained by the fact that a worldwide 3-dimensional FDI database was until recently not available. Several CGE models like MIRAGE (Decreux and Valin (2007)) or the GTAP model (Hertel (1997)) were designed to enable cross-border investments, but did not capture important economic characteristics of FDI. Demand and production characteristics of foreign affiliates were indeed not modeled as distinct from those of domestic firms. The reasons for the existence of multinational firms were well described in models of the multinational enterprises and notably in Markusen's work (2002). However, these models are hard to calibrate in world CGE models due to lack of data. For this reason, Petri's contribution (1997) was decisive in providing a way to model some important characteristics of FDI in multi-country CGE models.

3.1. Models of the multinational enterprise

The differences between multinationals and local firms were already identified in Dunning's "eclectic" theory (1985). His OLI paradigm (Ownership-Location-Internalization) provides a theoretical framework for the existence of multinational firms. Multinational firms own a firm-specific asset (FSA) – for example technological advance or managerial expertise – and can decide to locate (part of) their production abroad in order to benefit from a site specific asset (SSA) – for example a site close to the consumers or where production costs are low. This approach can explain both *market seeking* investments – or horizontal FDI – as well as *efficiency seeking* investments – or vertical FDI – of multinational firms. Dunning's theory was translated in mathematically tractable models by Brainard (1993), Helpman (1984) and in particular in Markusen's *Knowledge-capital model* (1996). Markusen formalized Dunning's approach in describing a 2 goods x 2 factors x 2 countries model, where he assumes (i) that consumption and production of knowledge services can be geographically separated from production and supplied at a low marginal cost, (ii) that headquarters services are skilled labor intensive and (iii) that knowledge services are partly joint-inputs, which means that they can be used simultaneously by several production centers. The *Knowledge-capital model* explains the existence of multinational firms: contrary to local firms, they benefit from economies of scale on knowledge services that they use simultaneously in different countries. Markusen's model also enables us to understand the different strategies of multinationals – export, horizontal or vertical FDI – as a function of the relative sizes and factor endowments of countries. Markusen, Rutherford and Tarr (2005) have applied the *Knowledge-capital model* in a one-country CGE. However, the authors did not calibrate the full model because of the absence of data on knowledge-capital transfers from the head office to the daughter company. This absence of data has prevented authors from directly applying the *Knowledge-capital model* to so-called "empirical CGE models" based on data from real economies like MIRAGE.

3.2. FDI modeling using Petri's framework

Petri's pioneering approach (1997) enables important characteristics of multinational production on demand to be taken into account. Petri has extended the so-called "Armington assumption" widely used in CGE models to the production of multinational firms in a given country. In his model, goods are differentiated by their country of production but also by the country of ownership of the firm.[1] Consumers now distinguish between goods based on the location of production, but also based on the origin of capital.

One of the characteristics of Petri's approach is that consumers decide between the origins of capital[2] at the first stage of the consumer decision tree. At a second stage, they decide on the location of production: at home or abroad. In Petri's modeling structure, products of different affiliates of a given multinational company are more substitutable than products of different multinational companies produced in the same country. For example, a Japanese car[3] produced in the United States will be more substitutable to a Japanese car produced in Japan than to an American car produced in Japan. Petri also models different production functions between multinational and local firms. He estimates technology links and intermediate input flows between subsidiaries and the parent company using survey data. Finally, he models barriers to FDI as a tax on profits, which does not absorb productive resources.

Petri applies this modeling to the APEC (Asia-Pacific Economic Cooperation) liberalization process with a 3-sector, 6-region model in a perfect competition setting. He concludes that the inclusion of FDI liberalization mechanisms strongly enhances the welfare gains of the liberalization process in the APEC region.

[1] Or the country where the head office of the multinational is located.

[2] Or between the nationalities of multinational firms.

[3] Or more precisely a car whose brand is Japanese.

3.3. Other models using Petri's framework

Several authors have introduced different specification into Petri's framework. Hanslow (1999) analyses the impact of liberalizing FDI barriers in the services sector in a 19-region 3-sector setting, the "FDI and Trade Analysis Project" (FTAP) model. Verikios and Zhang (2001) introduced some more sectoral detail in the FTAP model by disaggregating the tertiary sector into six subsectors. They also introduced large-group monopolistic competition within a Dixit-Stiglitz framework. However, they considered that these features had little impact on the results. Lee and van der Mensbrugghe (2001) also adopted Petri's approach in a 6-region model to evaluate the impacts of APEC trade and investment liberalization. Interestingly, they consider the role of profit repatriation by MNFs. FDI-based capital is assumed to operate as a joint venture in their model and only a fixed share of after-tax capital remuneration flows overseas. However, the main differences with Petri's model come from the fact that authors adopt a different nesting of the CES functions in the demand tree from the one chosen by Petri. In the FTAP model as well as in Lee and van der Mensbrugghe's model, consumers first decide among the production location of goods and at the second level of the demand tree between the origins of capital. The authors consider that this inverted demand tree is closer to reality, particularly in the services sectors. As Lee and van der Mensbrugghe mention, foreign banks provide very similar types of services in a given country regardless of the country where the bank is headquartered. In these two models, goods and services provided by domestic and foreign owned firms in a given location appear to be closer substitutes than those provided by firms headquartered in the same country but produced in different locations.

Since we consider that Petri's demand nesting order is well suited to the manufacturing sector but that the inverted nesting order is better suited to the services sector, we adopt a different demand tree in MIRAGE for services and manufacturing sectors. The use of a worldwide FDI database matching GTAP nomenclature also enables us to choose a geographical and sectoral aggregation among the 113 regions and 57 sectors of GTAP. However, the modeling of FDI in MIRAGE expands the dimensionality of the model because trade variables for example have a sector dimension, a country of origin and a country of destination dimensions, but also an ownership dimension. For this reason, the sectoral and geographical aggregation needs to be relatively simple but can focus on some particular GTAP regions and sectors. To reduce complexity, we have also assumed perfect competition between goods and services of a given production location and origin of capital instead of the Cournot-Nash imperfect competition described in Decreux and Valin (2007). We have also assumed that the totality of after-tax capital remuneration was repatriated to the headquarter region. Barriers to FDI, technological and intermediary input flows between subsidiaries and parent companies as well as different hypotheses concerning profit repatriation could be introduced in MIRAGE in future work. More recently, other interesting specifications have been introduced in CGE models including an explicit modeling of multinational firms. Rutherford and Tarr (2008) have abandoned the assumption of the representative agent by introducing a large number of households to assess the impact of the accession of Russia to the WTO on income distribution. Latorre et al. (2009) have used recent data (OECD, 2007) to model MNFs technologically differentiated from national firms in a 20 sector model for the Czech Republic.

4. FDI modeling in MIRAGE

The MIRAGE model was originally designed to enable cross-border investments. Multinational firms were however not explicitly modeled and goods produced with local capital were not differentiated from other domestically produced goods and services. Our new modeling aims to better take into account the effects of FDI on demand. We have thus explicitly modeled the production of goods using foreign capital distinct from the production of goods using local capital. For this reason, this new version of MIRAGE will be called the "MNF version", where MNF stands for multinational firm, while the original version is called the "Portfolio version". In order to highlight the consequences of our new modeling, we will compare in the next part results of simulations using the "MNF version" with those obtained using the "Portfolio version".

4.1. Investment decision in MIRAGE

Installed capital is assumed to be immobile in MIRAGE. Capital stock gradually adjusts through investment and amortization. A single generic gravity formulation is used for setting both domestic and foreign investment. It consists of allocating the savings from region *r*, S_r, as a function of the initial investment pattern represented by the calibrated parameter $A_{i,r,s}$ and of the rate of return of sector *i* in the region *s*, $W^K_{i,s}$, with an elasticity α:

$$\frac{P^K_s I_{i,r,s}}{S_r} = \frac{A_{i,r,s} P^K_s K_{i,s} \mathrm{e}^{\alpha W^K_{i,s}}}{\sum_{i,s'} A_{i,r,s'} P^K_{s'} K_{i,s'} \mathrm{e}^{\alpha W^K_{i,s'}}}$$

where P^K_s is the price of investment, $I_{i,r,s}$ is the investment of the representative agent from region *r* in the sector *i* of the region *s* and $K_{i,s}$ is the installed capital stock. Head and Ries (2008) have derived an investment equation from a theoretical model in which FDI decisions are the results of auctions for corporate control which appears to be very close to this formulation. The value chosen for the parameter α, which sets the adjustment speed of capital stocks, will be later examined.

For the initial year (2004), FDI flows and stocks are calibrated using the worldwide bilateral sectoral database of Boumelassa et al. (2007) whereas total investment and capital stock come from GTAP data. The allocation of investment in every sector and region will then evolve as a function of the relative variations of return to capital. Furthermore, it is assumed that other drivers of investment like risk premiums and patterns of diversification are taken into account through the calibrated parameter $A_{i,r,s}$ and that capital returns incorporate the influence of FDI determinants identified in the literature such as market size, growth rate or market potential.

4.2. The "Portfolio version"

In this version of MIRAGE, regional agents have the possibility to invest in other countries or regions but goods produced are not differentiated by their origin of capital. They are only distinguishable by their production location: there is no distinction between a good produced with local capital and a good produced with foreign capital in the same region. Foreign investors will therefore invest in the most profitable regions and sectors without changing consumers' perception of the firm's production. In this sense, cross-border investment is more similar to portfolio investment.

4.2.1. Supply structure of the "Portfolio version"

The supply structure of the "Portfolio version" is documented in Decreux and Valin (2007). Five production factors are used: capital, skilled labor, unskilled labor, land and natural resources. In a standard fashion, value added and intermediate consumption are assumed to be perfectly complementary. Value added is a CES function of land or natural resources and a nested CES of unskilled labour on the one hand and a capital and skilled labour on the other hand. The sectoral composition of the intermediate consumption aggregate also stems from a CES function. Differences between these two variants relate to the specification of demand for goods and services, more precisely the allocation of demand within a given sector according to where and by whom it is produced.

4.2.2. Demand structure of the "Portfolio version"

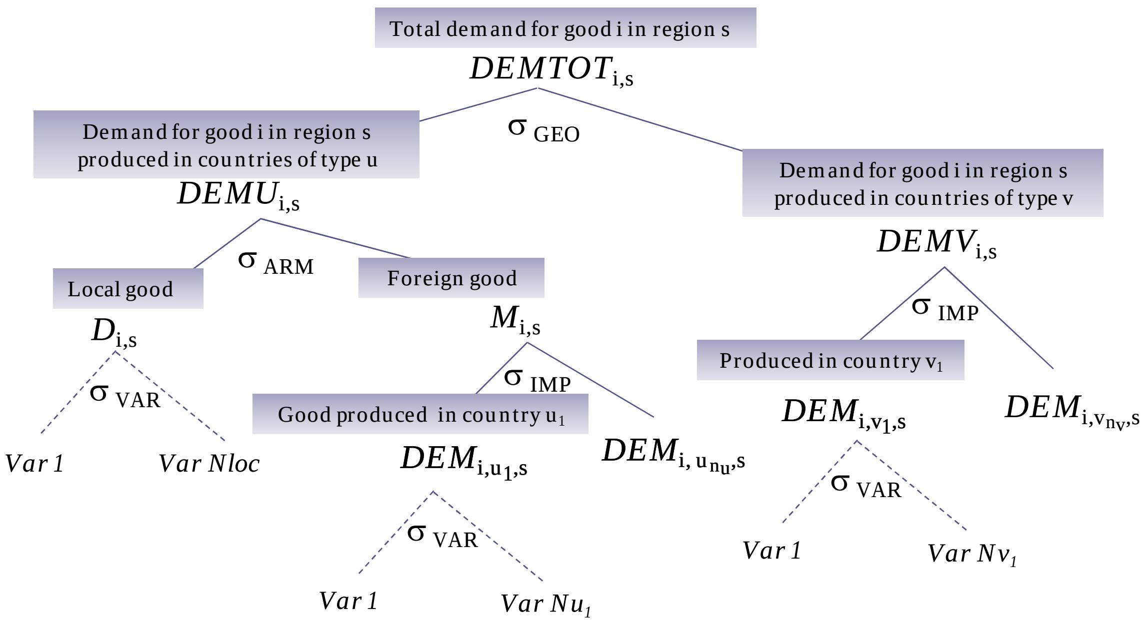


Figure 1: Demand tree of the "Portfolio version"

The demand structure of the "Portfolio version" is also documented in Decreux and Valin (2007). The demand tree consists of a nesting of CES function which allows the particular status of domestic goods, together with product differentiation according to geographical origin (the so-called Armington assumption) and horizontal product differentiation between varieties. A further CES nesting level is added, distinguishing between two quality ranges, defined on a geographical basis: goods produced in a developing economy are assumed to belong to a different quality range from those produced in a developed economy.

As presented in Figure 1, consumption budget is first allocated across sectors by the representative agent. Consumption in a given sector is then vertically differentiated between goods produced in countries of the same quality level as country s, $DEMU_{i,s}$, and those of a different quality level, $DEMV_{i,s}$ with an elasticity σ_{GEO}. Among goods of the same quality level, local goods are differentiated from foreign goods, following the Armington assumption, with an elasticity σ_{ARM}. Imports demands, whether they come from regions of the same quality level $M_{i,s}$ or from regions of a different quality level $DEMV_{i,s}$ are differentiated between their countries of origin with an elasticity σ_{IMP}. Finally, the last stage of the demand trees consists of horizontal differentiation of goods between varieties with an elasticity σ_{VAR}.

4.3. The "MNF version"

One of the limits of the MIRAGE model as described in the "portfolio version" was that the origin of capital was not taken into account in the allocation of the budget consumption between goods. It is however essential to better take into account the interactions between FDI and international trade in a model like MIRAGE designed for trade policy analysis. Theoretical and empirical literature has indeed emphasized both complementarity and substitution effects between FDI and international trade. By differentiating products by production location but also by origin of capital, the "MNF version" of MIRAGE is an important step towards a satisfying modeling of the demand for affiliate production of multinationals and therefore of the interactions between trade and FDI.

4.3.1. Supply structure of the "MNF version"

The modification of the supply side of the model in the "MNF version" consists in the perception by consumers in each sector of every country[4] of foreign firms as different from local firms. Production in each region is divided between the production of local firms and the production of foreign firms. Foreign firms are identified by their origin of capital using a supplementary index, rk. The same production functions as in the "portfolio version" and the same calibration parameters are used[5] between local and foreign firms. Total production is also assumed to be split between local firms and foreign firms in proportion to capital in the initial year and production factors other than capital are assumed perfectly mobile within a given sector. Factor demand by local and foreign-owned firms will then evolve independently in function of the demand addressed to each goods of a given production location and a given origin of capital.

[4] There are actually foreign firms from region *rk* – *rk* referring to the origin of capital – only in the regions and sectors where there were FDI flows and stocks in the calibration year.

[5] The reason for this choice is that the data do not detail the use of production factors by origins of capital.

The formulation for setting investment decisions is the same in the "MNF version" as in the "Portfolio version" except that capital in each sector of each country is divided between local capital, $Kloc_{i,s}$, and foreign capital from region *rk*, $KFDI_{rk,i,,r,s}$. Only domestic investors can invest in local firms and only foreign investors from region *rk* can invest in foreign firms from region *rk*.

4.3.2. Demand structure of the "MNF version

In addition to differentiating goods according to the ownership of the capital used to produce them, we adopt a different modeling of the demand structure between industrial goods and services. We assume like Petri (1997) that industrial goods are first differentiated by their origin of capital and then by their production location. In the automotive industry for example, this assumption means that two cars from the same origin of capital – which often means from the same brand or products with the same characteristics – produced in two different countries are closer than two cars of different origin of capital produced in the same country. However, as mentioned by Lee and van der Mensbrugghe (2001), an inverted order of differentiation is more adapted to the services sectors. We have for this reason modeled a different demand structure in the services sectors.

4.3.2.1. Demand structure of the "MNF version" for services

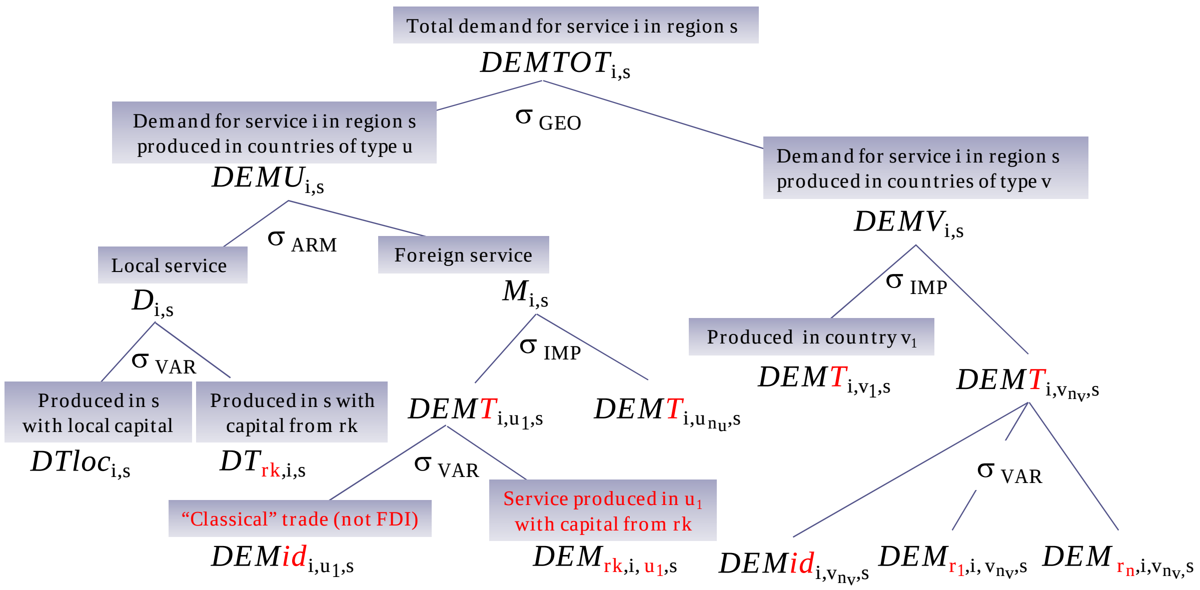
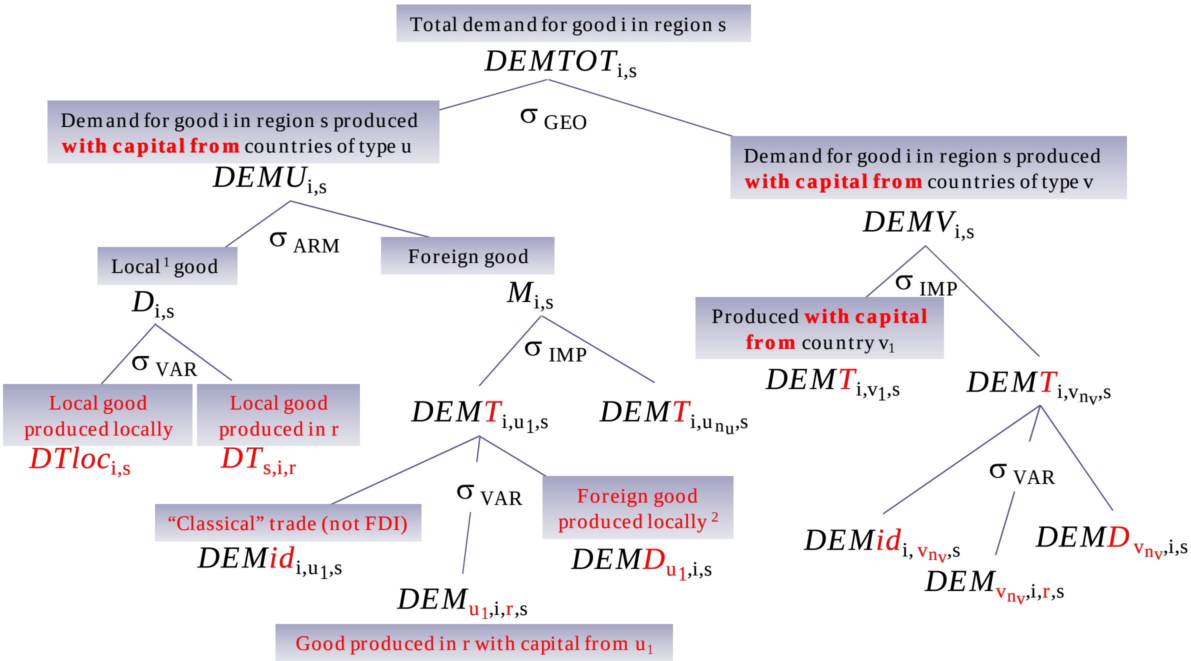


Figure 2: Demand tree of the "MNF version" for services

The first two stages of the demand tree of the "MNF version" for services are the same as in the "Portfolio version". Services are still first differentiated between services produced in countries of the same quality level than country s, $DEMU_{i,s}$, and those of a different quality level, $DEMV_{i,s}$ with an elasticity σ_{GEO}. Local services are differentiated from foreign services following the Armington assumption with an elasticity σ_{ARM}. The differentiation between origins of capital is then introduced at the 3rd and 4th stage of the demand tree. Among local services, services are differentiated between origins of capital with an elasticity σ_{VAR}. We assume that two services produced in the same country are highly substitutable which implies a high value of σ_{VAR}[6]. Following the same approach, foreign goods produced in u_1, $DEMT_{i,u1,s}$, are also differentiated between origins of capital with an elasticity σ_{VAR} : the imports of services produced by local firms in u_1, $DEMid_{i,u1,s}$, and the imports of services produced by foreign firms in u_1 , $DEM_{rk,i,u1,s}$. It is interesting to note that when u_1 is a group of countries, our modeling also takes into account intra-regional FDI. For example, if u_1 is the European Union, $DEM_{u1,i,u1,s}$ refers to services produced in the European Union but by firms owned by a country distinct from their country of production.

4.3.2.2. Demand structure of the “MNF version” for industrial goods



Note : 1) Here “local” means produced by a firm whose capital is local, i.e. from s.
2) Good produced and consumed in s, but produced by foreign owned firms .

Figure 3: Demand tree of the “MNF version” for industrial goods

We adopt Petri’s approach for industrial goods. The representative agent now first differentiates vertically between goods produced by firms which **capital** is from regions of the same quality level as his own, $DEMU_{i,s}$, and goods produced by firms which **capital** is from regions of a quality level different from his own, $DEMV_{i,s}$, with an elasticity σ_{GEO}. For industrial goods, the level of quality is determined by the **region of ownership** of the firms, whereas it is determined by the production location for services. Among goods of the same quality level, the Armington assumption is now used to differentiate between goods produced with local capital[7] and goods produced with foreign capital[8] – locally or abroad – with an elasticity σ_{ARM}. The demand for goods produced locally or abroad by foreign owned firms from the same quality level $M_{i,s}$ or from a different level of quality $DEMV_{i,s}$ are

[6] The value used for the simulations is $\sigma_{VAR} = 50$.

[7] Capital from s.

[8] Capital from rk ≠ s.

differentiated between the different possible origins of capital[9] with an elasticity σ_{IMP}. A supplementary stage is added where demand for goods is differentiated by the different production location of a multinational firm. Since this differentiation is similar to a horizontal differentiation – for example, in the automotive industry, a multinational often produces different models of cars in different countries[10] – and goods of the same multinational are assumed to be easily substitutable, the elasticity chosen, σ_{VAR}, is high.[11] Among local goods, local production is also differentiated between local firms production, $DTloc_{i,s}$, and imported production by local multinationals from region r, $DT_{s,i,r}$ – also called in Japan "boomerang imports". Among goods from a region of origin of capital, for example u_1, the representative agent also differentiates between goods produced by local firms in u_1 , $DEMid_{i,u1,s}$ and goods produced by multinationals from u_1 in other countries, for example in r, $DEM_{u1i,r,s}$ with the elasticity σ_{VAR} as well as goods produced by foreign multinationals in s, $DEMid_{i,u1,s}$. These goods are not imported – they are produced and consumed in s – but are still considered as foreign goods as far as demand is concerned because they are produced by a foreign multinational firm.

[9] Or in a multinational model terminology, the region where the multinational has its headquarters.
[10] We assume here that two models of car of the same brand – or of two multinationals whose head offices are located in the same region– produced in different countries are more substitutable than two models of cars of two different brands.
[11] Assuming that products of a single firm are perfectly homogeneous is not possible in a perfect competition framework, as the same product, coming from different regions of production, may be present in two different markets, while the difference in transport costs would not be the same. If price are identical in one of these markets, they have to differ in the other one.

5. Simulations results

The “Portfolio version” and the “MNF version” of MIRAGE presented in the last section are two complementary visions of foreign investment. In the portfolio vision, firms using (partly) foreign capital are not differentiated from local firms by consumers. In the MNF vision, the totality of FDI is considered to be invested by multinational firms. In industrial sectors, goods produced by an affiliate of a multinational will not compete directly with local goods because they are supposed to be close substitutes to goods produced in the country where the multinational is headquartered. In the services sectors, services produced by an affiliate of a multinational will compete more directly with local services because they are supposed to be more substitutable. Cross-country investment is generally considered as foreign direct investment when the investor owns more than 10% of the firm he invests in. This arbitrary threshold does not enable one to distinguish between investments made by individuals or banks and *greenfield* or *brownfield* investments made by multinationals. Even mergers and acquisitions (M&As) by multinationals cannot be easily isolated in the statistics. In this last case, the multinational can either choose to keep the brand of the foreign company acquired or replace it by its own brand. These two strategies will have different impacts on the way the consumers perceive the goods produced by the multinational firms. Our two modeling of FDI in MIRAGE are for these reasons complementary. After describing the assumptions made about the production of affiliates in the MNF version, we will focus in this section on the competition between local capital companies and FDI ones in the two versions of the model. Finally, we will analyze how both models respond to a fiscal shock.

5.1. Description of the simulations

5.1.1. Geographical and sectoral aggregation

The fiscal shock described below is mainly used to illustrate the impacts of our new modeling on simulations results. Since using a large number of regions and sectors would complicate our comparisons, we have used a relatively simple 10-region 4-sector setting. We also use GTAP 7 national corporate tax rates. Even if our modeling of multinational firms’ behavior can be useful to analyze the impacts of fiscal policy, the “MNF version” of MIRAGE is not yet adapted to a detailed analysis of fiscal policy. Such a study would require a more detailed modeling of financial markets in MIRAGE as well as more precise measures of corporate taxation. Belgium and France have been isolated from the rest of the European Union to enable us to simulate fiscal shocks in a relatively small country where FDI accounts for a high share of capital and in a relatively large one. The economy is disaggregated between four sectors: two sectors without FDI – agriculture and non tradable services[12] – and two sectors with FDI – industry and other services.

[12] Composed of two GTAP sectors: *Public Administration, Defense, Education, Health* and *Dwellings*.

	Sectors		
	Industry	Other Services	All
Belgium	51%	90%	48%
Other developed	19%	24%	15%
France	10%	19%	13%
Other EU27	14%	16%	13%
USA	10%	19%	8%
China & Hong-Kong	2%	19%	7%
Latin America & Caribbean	1%	15%	5%
Other Asia	4%	9%	5%
Other developing	2%	6%	3%
Japan	1%	0%	0%

Table 1 : FDI stock shares in total capital stock by region and sector at calibration year (2004)

Belgium ranks first in FDI stock among the regions considered both in industrial and services sectors. France FDI stock is slightly higher than the European Union average.

5.1.2. Affiliate production in the MNF version

As mentioned above, affiliate production might be overestimated because investments made by multinationals only represent a part of FDI but also underestimated because we assume that affiliates have the same production functions as local firms.[13] It is difficult to have an accurate estimation of affiliate production because national data do not generally provide the detail of the use of production factors between local and foreign firms. We have therefore assumed that all production factors were split in proportion of capital. Since the production functions used have constant returns to scale, the share of affiliate production in total production is the same as the share of FDI stock in total capital for each sector. Despite the imperfection of this estimation of affiliate production, it can be interesting to compare the share of affiliate production in the model with the share of total production exported and with the ratio of imports in total production. In the "MNF version", affiliate production will indeed compete directly with imports from the same region as the one where the multinational is headquartered. This is due to the fact that affiliate production is very substitutable with production from the headquarter region of the multinational in the consumer' demand function.

[13] Markusen's Knowledge-capital model (1996) suggests however that multinationals are more productive than local firms.

	Industry		
	Affiliate production	Exports	Imports
Belgium	51%	64%	71%
Other developed	19%	36%	34%
Other EU27	14%	30%	30%
USA	10%	12%	20%
France	10%	25%	26%
Other Asia	4%	37%	31%
China & Hong-Kong	2%	22%	19%
Other developing	2%	37%	30%
Japan	1%	17%	11%
Latin America & Caribbean	1%	23%	23%

Table 2: Share of affiliate production, exports and imports in total production of industrial sectors

	Other Services		
	Affiliate production	Exports	Imports
Belgium	90%	92%	82%
Other developed	24%	28%	32%
China & Hong-Kong	19%	27%	11%
USA	19%	21%	10%
France	19%	22%	33%
Other EU27	16%	22%	31%
Latin America & Caribbean	15%	18%	11%
Other Asia	9%	15%	14%
Other developing	6%	12%	10%
Japan	0%	2%	7%

Table 3: Share of affiliate production, exports and imports in total production of other services

5.2. Competition between affiliate production and local production

Before introducing a fiscal shock, we analyze the differences of FDI flows in a reference scenario between the two versions of the model.

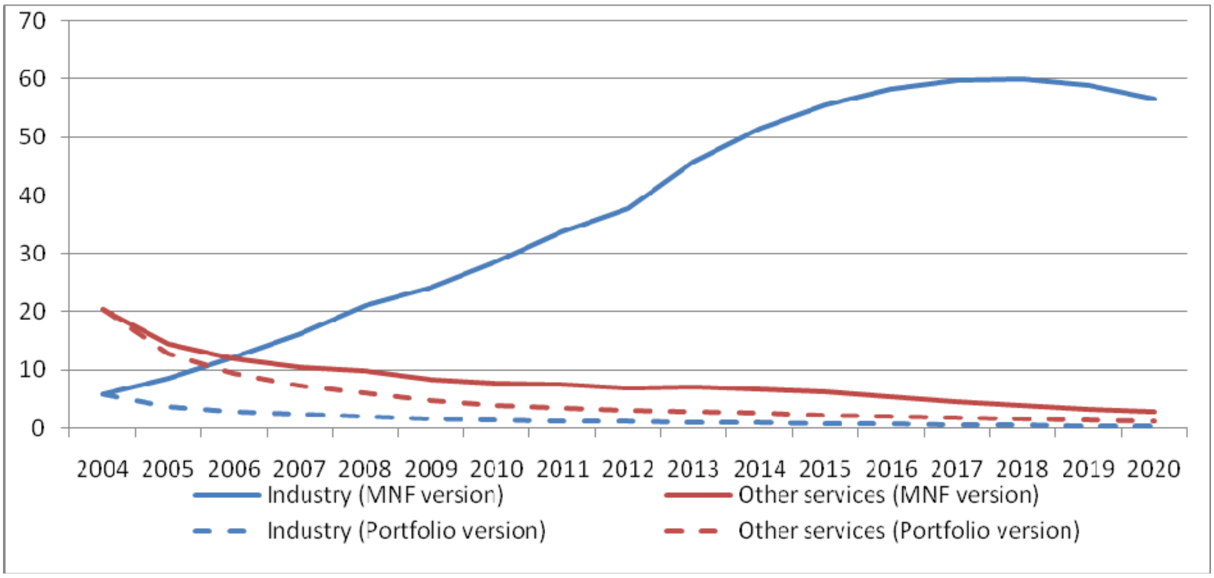


Figure 4: FDI inflows to China in the reference scenario (US$ billion)

In industrial sectors, FDI inflows to China strongly increase in the "MNF version" until 2017 then slightly decrease, while they decrease from 2004 to 2020 in the "Portfolio version". FDI in services also decrease in the "MNF version" but less than in the "Portfolio version". These differences come from the fact that FDI competes less with local investment in the "MNF version" than in the "Portfolio version", particularly in industrial sectors.

Capital return (reference scenario)	2004	2010	2015	2020
FDI in China (MNF)	15.8%	16.4%	16.3%	15.3%
FDI in China (Portfolio)	15.8%	13.1%	11.6%	9.6%
Local capital in China (MNF)	15.8%	13.2%	11.5%	9.2%
Local capital in China (Portfolio)	15.8%	13.1%	11.6%	9.6%

Table 4: Capital return before taxes of FDI and local investment in China in the reference scenario (industrial sectors)

Table 4 describes the evolution of capital return of FDI and local investment in industrial sectors in China. In both versions of the model, capital return of local investment decreases in China. This decrease in capital return in spite of important increase of total factor productivity (TFP) in China during the period is due to very high saving rates and thus local investment which drives down capital return. In the "Portfolio version", the evolution of FDI return is exactly the same as the one of local capital: it decreases from 15.8% to 9.6%. Indeed, both local capital and FDI are allocated to the same production in the "Portfolio version". In the "MNF version", the evolution of FDI return is totally different from the one of local capital. These differences come from the fact that local and foreign capital are not allocated to the same production: local production for local capital, production of multinationals affiliates for foreign capital. These two productions do not compete directly because they target two different demand segments: demand for goods of Chinese brand for local production and demand for goods of foreign brand for affiliate production.

Capital return (reference scenario)	2004	2010	2015	2020
FDI in China (MNF)	15.8%	14.2%	13.4%	11.6%
FDI in China (Portfolio)	15.8%	13.1%	11.6%	9.6%
Local capital in China (MNF)	15.8%	13.2%	11.6%	9.3%
Local capital in China (Portfolio)	15.8%	13.1%	11.6%	9.6%

Table 5: Capital return before taxes of FDI and local investment in China in the reference scenario (other services sector)

Affiliate production in services in the "MNF version" competes more directly with local production. For this reason, the return of FDI in services follows the same trend as the return of local capital. However, FDI return in services decreases less in the "MNF version" (11.6% in 2020) than in the "Portfolio version" (8.6% in 2020). Consequently, FDI inflows to China decrease less in the "MNF version" than in the "Portfolio version" (see Figure 4). Capital returns in industrial sectors and in services remain very close in the "Portfolio version" where the demand structure is the same between industrial sectors and services.

5.3. Reaction to a fiscal shock in France and Belgium

5.3.1. Scenario description

In this section, we simulate an exemption of corporate taxes on foreign capital. Corporate tax rates used for the simulation come from GTAP 7 database.

	Local capital	Foreign capital	
		Exemption in France	Exemption in Belgium
Japan	12.0%	12.0%	12.0%
Latin America & Caribbean	11.4%	11.4%	11.4%
USA	11.1%	11.1%	11.1%
Belgium	11.1%	11.1%	0%
Other developed	10.8%	10.8%	10.8%
France	9.2%	0%	9.2%
Other EU27	8.6%	8.6%	8.6%
Other developing	8.2%	8.2%	8.2%
Other Asia	6.2%	6.2%	6.2%
China & Hong-Kong	1.5%	1.5%	1.5%

Table 6: Corporate tax rates of local and foreign capital

We can notice that this corporate tax rates are much lower than statutory rates (33% in France for example). The reason for this difference is that the corporate tax rates we use apply to a much broader tax base than statutory rates. Statutory tax rates only apply to corporate income, whereas the tax rates used in MIRAGE apply to total capital revenues.[14] In both scenarios – exemption in France and exemption in Belgium – foreign capital is exempted from 2010 to 2020.

5.3.2. Exemption in France

	Scenario: FDI exempted of corporate tax in France					
	In industry and services		Only in industry		Only in services	
Year	"MNF"	"Portfolio	"MNF"	"Portfolio	"MNF"	"Portfolio
2010	0.32	0.56	0.07	0.13	0.26	0.42
2011	0.27	0.44	0.08	0.12	0.19	0.32
2012	0.24	0.36	0.08	0.11	0.15	0.27
2013	0.23	0.33	0.09	0.11	0.14	0.25
2014	0.22	0.32	0.10	0.11	0.13	0.24
2015	0.22	0.32	0.10	0.12	0.12	0.24
2016	0.22	0.34	0.11	0.12	0.11	0.25
2017	0.23	0.35	0.11	0.13	0.11	0.26
2018	0.23	0.37	0.12	0.14	0.11	0.27
2019	0.24	0.40	0.12	0.14	0.11	0.29
2020	0.24	0.42	0.12	0.15	0.12	0.30

Table 7: Welfare variations in France in relation to the reference scenario (in %)

We focus on the consequences of the fiscal shock in terms of welfare. An exemption of corporate tax on foreign capital increases welfare in France in both versions of the model. This is also the case if foreign capital is only exempted in industrial or in services sectors. We notice however that welfare gains are about 60% higher in the "Portfolio version" than in the "MNF version".

To understand the origins of these differences, we need to examine how welfare variations are computed. In MIRAGE, a representative consumer maximizes a CES-LES (Constant Elasticity of Substitution – Linear Expenditure System) utility function under a budget constraint to allocate his income across goods. Welfare variation is computed as the equivalent variation of consumption budget which generates the same utility variations while keeping prices fixed. Since budget consumption is assumed to be a fixed share of the region's revenue, welfare variation is equal to the equivalent variation of the region's revenue:

$$\begin{aligned} REV_r \;=\; & RECTAX_r + \sum_{rk,i} W^{KFDI}_{rk,i,r} KFDI_{rk,i,r} + \sum_i W^{Kloc}_{i,r} Kloc_{i,r} \\ & + \sum_i (W^H_{i,r} H_{i,r} + W^L_{i,r} L_{i,r}) + \underbrace{\sum_i (W^{RN}_{i,r} RN_{i,r} + W^{TE}_{i,r} TE_{i,r}) - SOLD_r PIBMVAL}_{\text{Other revenues}} \end{aligned}$$

[14] The earnings before interests, taxes, depreciation and amortization (EBITDA) the firm generates in accounting terminology or the operating surplus in national accounts terminology.

The region's revenue can be split up into tax revenues (including corporate tax revenues), production factor revenues (foreign capital KFDI, local capital Kloc, skilled labor H, unskilled labor L, national resources RN and land TE) minus trade balance (which is assumed to be a fixed share of world GDP). Welfare variations can thus be broken down into the equivalent variations of tax revenues, capital revenues, labor revenues and other revenues (national resources and land revenues minus trade balance).

5.3.2.1. Decomposition of welfare variations

	Scenario: FDI exempted of corporate tax in France									
	Equivalent variations in "MNF version"					Equivalent variations in "Portfolio version"				
Year	Welfare	Labor revenues	Capital revenues	Tax revenues	Other revenues	Welfare	Labor revenues	Capital revenues	Tax revenues	Other revenues
2010	0.32	0.30	-0.10	0.12	0.00	0.56	0.47	-0.23	0.31	0.00
2011	0.27	0.46	-0.22	0.03	0.00	0.44	0.65	-0.39	0.17	0.00
2012	0.24	0.57	-0.30	-0.03	0.00	0.36	0.78	-0.49	0.07	0.00
2013	0.23	0.66	-0.36	-0.07	0.00	0.33	0.89	-0.56	0.01	0.01
2014	0.22	0.73	-0.40	-0.10	0.00	0.32	0.97	-0.61	-0.04	0.01
2015	0.22	0.78	-0.43	-0.12	0.00	0.32	1.03	-0.64	-0.07	0.01
2016	0.22	0.82	-0.45	-0.14	0.01	0.34	1.09	-0.66	-0.09	0.01
2017	0.23	0.85	-0.47	-0.15	0.01	0.35	1.14	-0.68	-0.11	0.01
2018	0.23	0.87	-0.47	-0.16	0.01	0.37	1.18	-0.69	-0.12	0.01
2019	0.24	0.88	-0.48	-0.17	0.01	0.40	1.22	-0.70	-0.13	0.01
2020	0.24	0.89	-0.48	-0.18	0.01	0.42	1.26	-0.70	-0.14	0.01

Table 8: Decomposition of welfare variations in France in relation to the reference scenario (in %)

We examine the origins of welfare variations due to the tax exemption. Nearly the totality of revenue variations come from labor revenues, capital revenues and tax revenues variations. In both versions of the model, labor revenues increase in the exemption scenario in relation to the reference scenario. Indeed, there is an increase of capital stock in France in the tax exemption scenario due to higher FDI inflows which make labor more productive. For this reason, both skilled and unskilled labor remuneration increases in France. The fact that tax revenues increase (then decrease less) in the "Portfolio version" than in the "MNF version" shows that capital stock increase more in the "Portfolio version" than in the "MNF version". The loss in corporate tax revenues is compensated by other tax revenues in the "Portfolio version". Capital revenues also decrease less in the "MNF version" because higher FDI inflows in the "Portfolio version" drive down more capital remuneration in the "Portfolio version" than in the "MNF version". It is important to note that only outward FDI and not inward FDI increase capital revenues in France because FDI remuneration flows overseas.

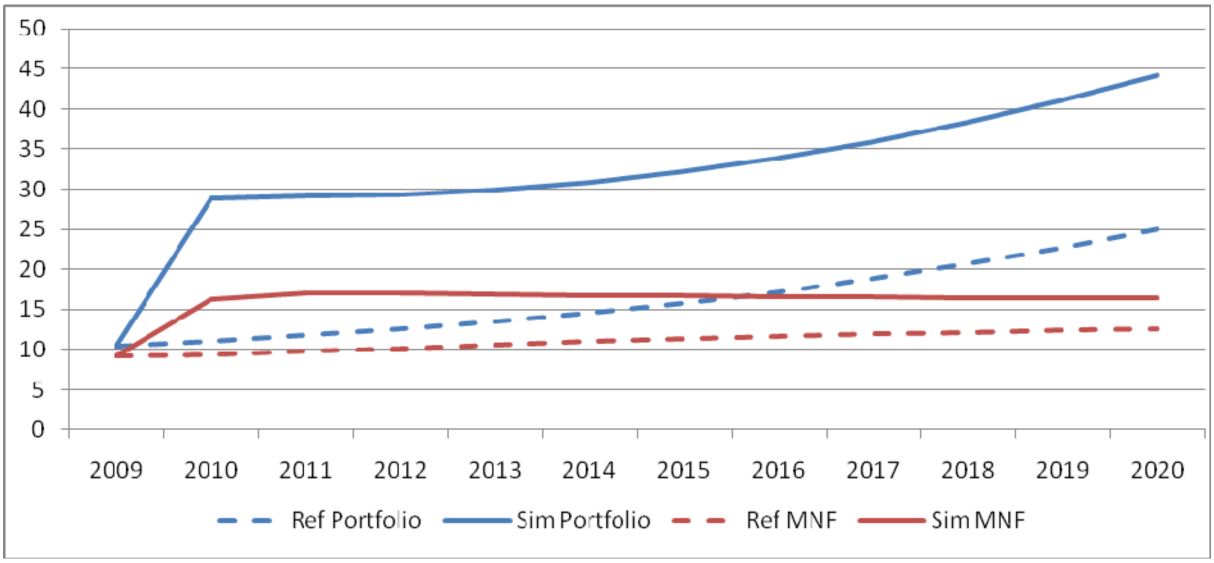


Figure 5: FDI inflows to France in industrial sectors (US$ billion)

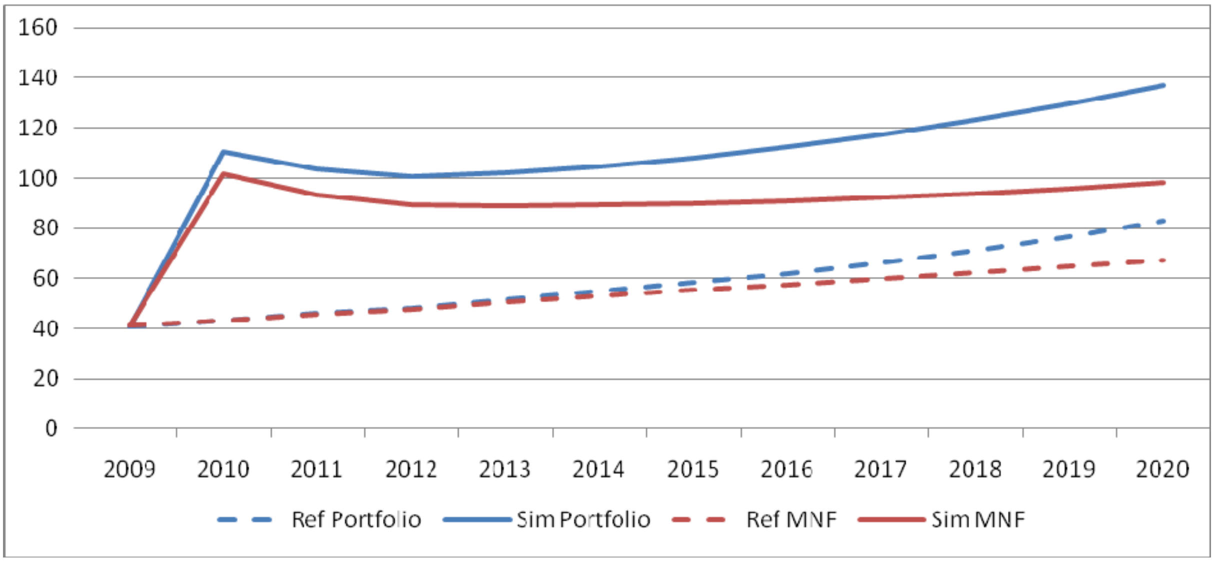


Figure 6: FDI inflows to France in services sectors (US$ billion)

FDI inflows to France increase indeed more in the “Portfolio version” than in the “MNF version”. As previously mentioned this difference comes from the fact that local and affiliate production target two different demand segments in the “MNF version”. It is not the case in the “Porfolio version” where local and foreign productions are not differentiated. FDI inflows are therefore lower in the “MNF version” than in the “Portfolio version” because the domestic demand for goods produced with foreign capital is rapidly saturated. This is all the more the case in industrial sectors where affiliate production is less substitutable with local production than in the services sectors.

5.3.3. Exemption in Belgium

	Scenario: FDI exempted of corporate tax in Belgium					
	In industry and services		Only in industry		Only in services	
Year	"MNF"	"Portfolio	"MNF"	"Portfolio	"MNF"	"Portfolio
2010	-0.76	-1.34	-0.15	-0.38	-0.62	-0.96
2011	-0.44	-1.13	-0.04	-0.38	-0.40	-0.75
2012	-0.28	-0.99	0.03	-0.37	-0.31	-0.61
2013	-0.20	-0.88	0.07	-0.36	-0.27	-0.52
2014	-0.16	-0.81	0.10	-0.35	-0.26	-0.45
2015	-0.14	-0.75	0.12	-0.34	-0.25	-0.41
2016	-0.12	-0.71	0.14	-0.33	-0.25	-0.37
2017	-0.11	-0.68	0.16	-0.32	-0.26	-0.35
2018	-0.11	-0.66	0.17	-0.32	-0.27	-0.34
2019	-0.10	-0.64	0.18	-0.31	-0.27	-0.33
2020	-0.10	-0.63	0.19	-0.30	-0.28	-0.32

Table 9: Welfare variations in Belgium in relation to the reference scenario (in %)

Unlike in France, an exemption of corporate tax on foreign capital is negative in Belgium when total capital is exempted. This is mainly due to the fact that the share of foreign capital in total capital is much higher in Belgium than in France: 48% of total capital in Belgium is foreign-owned against only 13% in France. For this reason, the loss of tax revenues due to corporate taxes is not compensated by higher labor revenues and other taxes revenues. This is also the case in both versions of the model when FDI is only exempted in other services sector where FDI stocks accounts for 90% of total capital in Belgium. The main difference between the two versions of the model appears when only foreign capital is exempted in industrial sectors. This scenario increases welfare in Belgium from 2012 in the "MNF version" whereas it decreases it in the "Portfolio version". We will therefore analyze more precisely the origins of the differences in this scenario.

5.3.3.1. Exemption in Belgium in industrial sectors

	Scenario: FDI exempted of corporate tax in Belgium in industrial sectors only									
	Equivalent variations in "MNF version"					Equivalent variations in "Portfolio version"				
Year	Welfare	Labor revenues	Capital revenues	Tax revenues	Other revenues	Welfare	Labor revenues	Capital revenues	Tax revenues	Other revenues
2010	-0.15	0.32	-0.08	-0.35	-0.03	-0.38	0.10	-0.09	-0.39	-0.00
2011	-0.04	0.49	-0.13	-0.35	-0.05	-0.38	0.18	-0.15	-0.39	-0.01
2012	0.03	0.57	-0.14	-0.35	-0.06	-0.37	0.23	-0.20	-0.39	-0.01
2013	0.07	0.62	-0.15	-0.34	-0.06	-0.36	0.27	-0.22	-0.39	-0.02
2014	0.10	0.64	-0.14	-0.33	-0.07	-0.35	0.30	-0.24	-0.39	-0.02
2015	0.12	0.65	-0.14	-0.32	-0.07	-0.34	0.32	-0.26	-0.39	-0.02
2016	0.14	0.65	-0.13	-0.31	-0.07	-0.33	0.34	-0.26	-0.38	-0.02
2017	0.16	0.65	-0.12	-0.30	-0.07	-0.32	0.35	-0.27	-0.38	-0.02
2018	0.17	0.65	-0.11	-0.30	-0.07	-0.32	0.36	-0.27	-0.38	-0.02
2019	0.18	0.64	-0.10	-0.29	-0.07	-0.31	0.36	-0.27	-0.38	-0.02

2020	0.19	0.64	-0.09	-0.28	-0.07	-0.30	0.37	-0.27	-0.37	-0.02

Table 10: Decomposition of welfare variations in France in relation to the reference scenario (in %)

In this scenario, we first notice that the variations of other revenues are not insignificant any more. This is mainly due to a variation of the trade balance due to FDI inflows which account for a significant part of total investment in Belgium. Like in the exemption scenario in France, labor revenues increase because of higher FDI inflows which make labor more productive. Capital revenues decrease because higher capital stock drives down capital remuneration. The loss of capital revenues is also higher in the "Portfolio version" than in the "MNF version". The main difference stems from the fact that the effects of the exemption are positive from 2012 in the "MNF version" whereas they are negative in the "Portfolio version". The reason for this difference is that the higher competition between local and affiliate production in the "Portfolio version" leads to a substitution of local capital by foreign capital in the "Portfolio version". This substitution of local capital by foreign capital also explains why capital revenues decrease more in the "Portfolio version" than in the "MNF version".

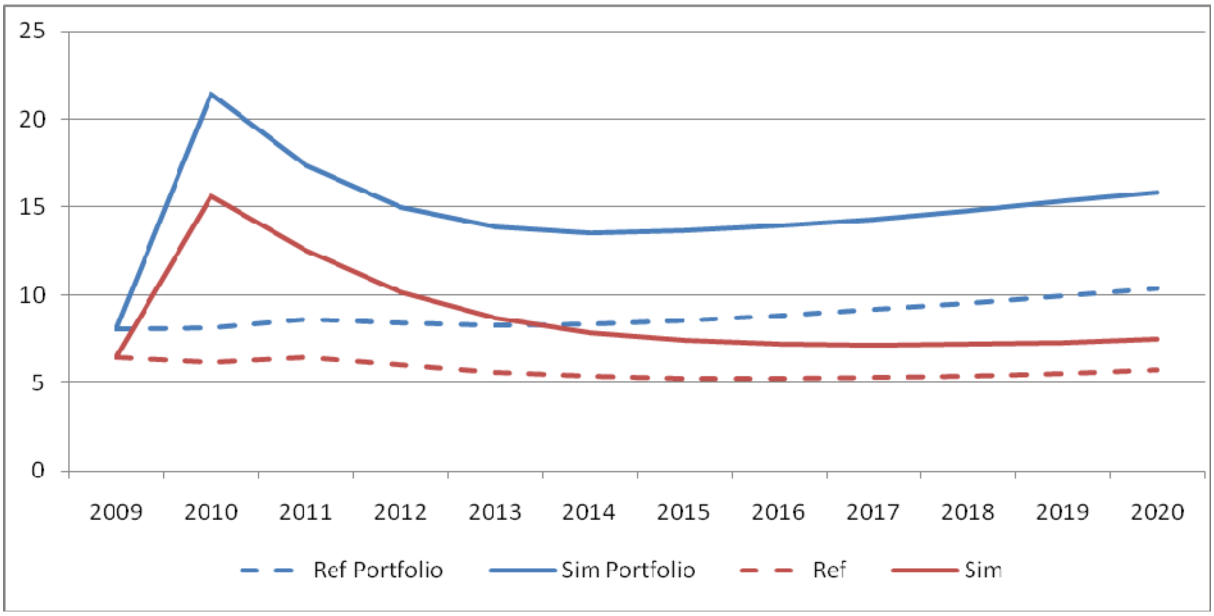


Figure 7: FDI inflows to Belgium in industrial sectors (US$ billion)

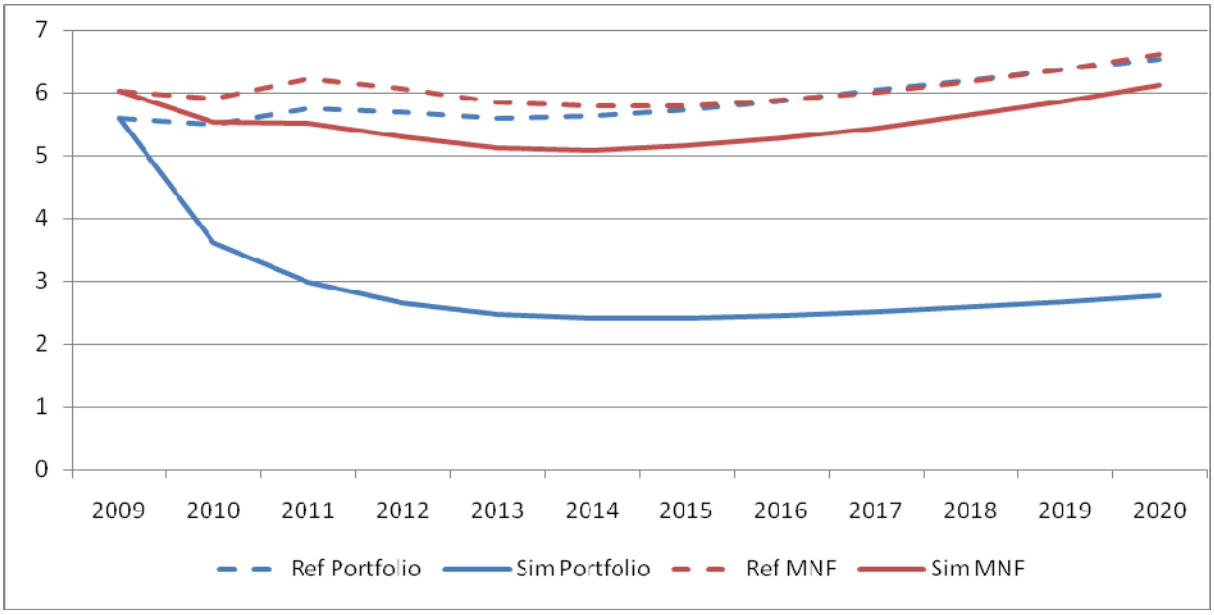


Figure 8: Local investment in Belgium in industrial sectors (US$ billion)

Figure 7 shows FDI inflows increase less in the “MNF version” than in the “Portfolio version”. This is due to the fact that affiliate production addresses domestic demand for foreign production which rapidly saturates. On the contrary, local investment decreases less in the “MNF version” than in the “Portfolio version”. Indeed, since production using foreign capital is not differentiated from local production in the “Portfolio version”, local capital can replace foreign capital to fulfill domestic demand for local goods in Belgium. The lower competition between local production and affiliate production in the “MNF version” of the model can therefore lead to different estimations of tax exemption effects on welfare. This example shows that taking into account the origin of capital in consumers’ demand function can change economic policy recommendations.

5.4. Sensitivity analysis

5.4.1. Value of the parameter α

In the simulations of an exemption of corporate taxes on foreign investment, the elasticity to capital return differentials – the parameter α of the investment function – sets the adjustment speed of capital. For this reason, the value of this parameter which cannot be calibrated needs to be chosen to match empiric estimates. In former versions of the MIRAGE model, the value of α was chosen so that half of the adjustment of capital stocks towards its long run target would be made in around four years, for a variety of small commercial shocks. It led to the value: α = 40. In this work, we have used empiric estimates of corporate tax elasticities to choose the value of α. Unfortunately, most studies use other measures of corporate taxation than the one used in MIRAGE. Most of the time, studies either use statutory tax rates or ex ante measures of corporate taxations – notably average effective tax rates (AETR) and marginal effective tax rates (EMTR) (see de Mooj and Ederveen (2008) for a meta analysis of corporate tax elasticities). Since only total capital revenues and not capital income are available in GTAP 7, we model in MIRAGE a tax on total capital revenues. Bénassy-Quéré, Fontagné and Lahrèche-Révil (2005) have estimated the elasticity of FDI to a measure of taxation inspired from Mendoza et al. (1994). Their apparent effective tax rate is computed as the ratio between corporate tax revenues and the operating surplus. They find a semi-elasticity of FDI to apparent effective tax rate (-9.39) much larger than the ones to the statutory tax rate, the EATR and the EMTR. This difference stems from the lower value in absolute terms of this measure of taxation. To estimate the semi-elasticity of FDI to corporate tax differentials in the MIRAGE model, we simulate a decrease of 1 point of corporate tax rate on FDI capital from 2010 to 2020. The semi-elasticity will be the opposite of the increase in percentage of foreign investment in the simulation scenario in relation to the reference scenario in 2010. In our simulations of tax exemption, we have chosen a value of α = 100. This value enables us to have similar estimates than Bénassy-Quéré, Fontagné and Lahrèche-Révil (2005).

	Scenario: decrease of 1 point of corporate tax on FDI in France, α=100					
	"MNF version"			"Portfolio version"		
Year	**Industry**	**Services**	**All**	**Industry**	**Services**	**All**
2010	7.6%	10.4%	9.9%	11.4%	11.2%	11.2%
2011	7.1%	9.1%	8.8%	11.0%	10.2%	10.4%
2012	6.4%	8.2%	7.9%	10.5%	9.5%	9.7%
2013	5.8%	7.5%	7.2%	10.0%	9.0%	9.2%
2014	5.2%	6.9%	6.6%	9.6%	8.6%	8.8%
2015	4.7%	6.4%	6.1%	9.2%	8.2%	8.4%
2016	4.3%	6.0%	5.7%	8.8%	7.9%	8.1%
2017	4.0%	5.6%	5.3%	8.4%	7.6%	7.8%
2018	3.7%	5.3%	5.0%	8.0%	7.3%	7.4%
2019	3.5%	5.0%	4.8%	7.7%	6.9%	7.1%
2020	3.3%	4.8%	4.6%	7.3%	6.6%	6.8%

Figure 9: Variations of FDI inflows to France in relation to the reference scenario (in %)

	Scenario: decrease of 1 point of corporate tax on FDI in Belgium α=100					
	"MNF version"			"Portfolio version"		
Year	**Industry**	**Services**	**All**	**Industry**	**Services**	**All**
2010	11.1%	8.5%	9.0%	12.3%	8.6%	9.5%
2011	8.5%	5.3%	5.9%	9.2%	5.4%	6.3%
2012	6.8%	3.7%	4.2%	7.6%	3.8%	4.6%
2013	5.6%	2.9%	3.3%	6.7%	3.0%	3.8%
2014	4.9%	2.5%	2.8%	6.3%	2.6%	3.4%
2015	4.3%	2.2%	2.5%	6.1%	2.3%	3.2%
2016	3.9%	2.1%	2.3%	5.9%	2.2%	3.0%
2017	3.6%	2.0%	2.2%	5.8%	2.1%	3.0%
2018	3.3%	1.9%	2.1%	5.7%	2.1%	2.9%

2019	3.1%	1.8%	2.0%	5.6%	2.0%	2.8%
2020	2.9%	1.8%	1.9%	5.5%	2.0%	2.8%

Figure 10: Variations of FDI inflows to Belgium in relation to the reference scenario (in %)

The value α = 100 leads to a value of semi-elasticity of -9.9 in France and of -9.0 in Belgium in the "MNF version". The semi-elasticity obtained in the "Portfolio version" is slightly higher, -11.2 in France and -9.5 in Belgium. This is mainly due to the fact already mentioned that FDI production and local production are differentiated in the "MNF version" and not in the "Porfolio version". In the "Portfolio version", the increase in FDI inflows is higher because FDI can replace local investment to produce local goods. In the "MNF version", the demand for affiliate production can be saturated which explains why FDI does not increase as much as in the "Portfolio version". The difference is smaller in the services sectors where demands function of the "MNF version" is closer to the one of the "Portfolio version" than in industrial sectors. Eventually, the semi-elasticity is also higher in France than in Belgium because the share of FDI in total capital is much lower in France than in Belgium.

5.4.2. Impacts on welfare of different values of α

	Scenario: all FDI exempted of corporate tax in France					
	"MNF version"			"Portfolio version"		
Year	**α=40**	**α=100**	**α=200**	**α=40**	**α=100**	**α=200**
2010	-0.12	0.32	0.97	-0.12	0.56	2.30
2011	-0.10	0.27	0.59	-0.11	0.44	0.90
2012	-0.08	0.24	0.44	-0.11	0.36	0.67
2013	-0.07	0.23	0.39	-0.10	0.33	0.65
2014	-0.05	0.22	0.36	-0.09	0.32	0.69
2015	-0.04	0.22	0.35	-0.09	0.32	0.75
2016	-0.03	0.22	0.35	-0.09	0.34	0.82
2017	-0.01	0.23	0.35	-0.08	0.35	0.87
2018	-0.01	0.23	0.36	-0.08	0.37	0.92
2019	0.00	0.24	0.37	-0.08	0.40	0.96
2020	0.01	0.24	0.38	-0.07	0.42	0.99

Figure 11: Welfare variations in France in relation to the reference scenario (in %)

	Scenario: all FDI exempted of corporate tax in Belgium					
	"MNF version"			"Portfolio version"		
Year	**α=40**	**α=100**	**α=200**	**α=40**	**α=100**	**α=200**
2010	-1.26	-0.75	-0.34	-1.34	-0.83	-0.36
2011	-0.97	-0.43	-0.15	-1.13	-0.66	-0.43
2012	-0.76	-0.28	-0.08	-0.99	-0.57	-0.42
2013	-0.62	-0.20	-0.06	-0.88	-0.53	-0.41
2014	-0.51	-0.15	-0.05	-0.81	-0.51	-0.41

2015	-0.43	-0.13	-0.05	-0.75	-0.50	-0.41
2016	-0.37	-0.11	-0.05	-0.71	-0.49	-0.41
2017	-0.33	-0.10	-0.05	-0.68	-0.49	-0.41
2018	-0.29	-0.09	-0.05	-0.66	-0.49	-0.41
2019	-0.26	-0.09	-0.05	-0.64	-0.49	-0.42
2020	-0.24	-0.09	-0.05	-0.63	-0.49	-0.42

Figure 12: Welfare variations in Belgium in relation to the reference scenario (in %)

The results of the simulations can be very different in relation to the value of α chosen. The lower the semi-elasticity to capital returns differentials, the higher the losses – or the lower the gains – in terms of welfare. This is due to the fact that the loss in corporate tax revenues is immediately incurred, whereas the gains due to higher FDI inflows depend of the adjustment speed of capital. For this reason, a tax exemption on FDI in France will have in both versions of the model negative consequences if the adjustment is slow – for example α = 40 – and positive consequences if the adjustment is fast – for example α = 100. These simulations show that the value of the semi-elasticity to capital returns differentials is critical to estimate the effects of any tax policy in a CGE framework.

Conclusion

References

Bénassy-Quéré, A., Fontagné, L. & Lahrèche-Révil, A. (2005), "How does foreign direct investment react to corporate taxation?", *International Tax and Public Finance*, Vol. 12, pp. 583-603.

Boumelassa H., Gouel, C. & Laborde, D. (2007), "Bilateral and Sectoral Investment Relations at a World Scale. Impact on Trade", Report for the Commission of the European Union – Directorate General for Trade.

Brainard S.L. (1992), "A Simple Theory of the Multinational Corporation and Trade with a Trade-off between Proximity and Concentration," NBER Working Paper No 4269.

Decreux Y. & Valin, H. (2007), MIRAGE, "Updated Version of the Model for Trade Policy Analysis Focus on Agriculture and Dynamics", Document de travail CEPII 2007-15.

Dunning, J.H. (1985), "Multinational Enterprises, Economic Structure and International Competitiveness", John Wiley and Sons.

Head K. & Ries, J.C. (2008), "FDI as an Outcome of the Market for Corporate Control: Theory and Evidence", *Journal of International Economics*, Vol. 74, pp. 2-20.

Helpman E. (1984), "A Simple Theory of International Trade with Multinational Corporations", *Journal of Political Economy*, Vol. 92, pp. 451-71.

Latorre M.C. (2009), "The economic analysis of multinationals and foreign direct investment: a review", *Hacienda Pública Española*, IEF, Vol. 191(4), pp. 97-126, December 2009.

Latorre M.C., BAJO-RUBIO, O. & GOMEZ-PLANA, A.G. (2009), "The Effects of Multinationals on Host Economies: a CGE approach", *Economic modelling*, Vol. 26, pp. 851-864.

Lejour A. & Rojas-Ramagosa, H. (2006), "Foreign Direct Investment in Applied General Equilibrium models" CPB Memorandum, December 2006.

Lee H. & Van DER Mensbrugghe, D. (2001), "A General Equilibrium Analysis of the Interplay between Foreign Direct Investment and Trade Adjustments", Kobe U. Research Institute for Economics & Business Administration, Discussion Paper No. 119.

Markusen J. R. (2002), "Multinational Firms and the Theory of International Trade", MIT Press, Cambridge.

Markusen J. R., Venables, A.J., Eby Konan, D. & ZHANG, K.G. (1996), "A Unified Treatment of Horizontal Direct Investment, Vertical Direct Investment, and the Pattern of Trade in Goods and Services", NBER Working Paper No. 5696.

Markusen J., Rutherford, T. & Tarr, D. (2005), "Trade and Foreign Direct Investment in Producers Services and the Market for Foreign Expertise", *Canadian Journal of Economics*, Vol. 38, pp.758-777.

Mendoza, E., Assaf, R. & Tesar, L. (1994), "Effective tax rates in macroeconomics: cross-country estimates of tax rates in factor incomes and consumption", *Journal of Monetary Economics*, Vol. 34, pp. 297-323.

de Mooj R., and Ederveen S. (2008), "Corporate tax elasticities: a reader's guide to empirical findings", *Oxford Review of Economic Policy*, Vol. 24, pp.680-697.

OECD (2007), "Measuring globalization. Activities of multinationals", OECD Press, Paris.

Petri A. (1997), "Foreign Direct Investment in a Computable General Equilibrium Framework," Brandeis-Keio Conference on "Making APEC Work: Economic Challenges and Policy Alternatives", Keio University, Tokyo.

Rutherford, T.F. & Tarr, D.G. (2008), "Poverty effects of Russia's WTO accession: Modeling "real" households with endogenous productivity effects", *Journal of International Economics*, Vol. 75, pp. 131-150.

UNCTAD (1996), "World Investment Report 1996: Investment, Trade and International Policy Arrangements".

UNCTAD (2009), "World Investment Report 2009: Transnational Corporations, Agricultural Production and Development".