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# Foreign Direct Investment and Innovations: Transmission Dynamics of Persistent Demand and Technology Shocks in a Macro Model

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**Abstract:**

A deeper macroeconomic analysis of foreign direct investment (FDI), innovation and other key variables is needed to better understand technology shock effects, transmission dynamics and policy perspectives in open economies. FDI outward stock relative to the source country total capital stock was above 10 percent in twelve OECD countries in 2019, including the UK and the US. This paper adds FDI to a standard model with a tradable and a non-tradable sector. Here, we define non-tradable in a broad sense. The non-tradable sector covers those firms which are located in the tradable sector but undertake FDI in order to overcome the costs associated with exports but it also includes firms in the service industry who offer services which are intrinsically non-tradable, but which can be offered internationally via subsidiaries. This relates to traditional services (e.g., in retail) but also to novel digital services. We study how opening up the non-tradable sector to international transactions (via FDI) affects the international transmission of technology shocks and of persistent demand shocks. We consider a wide range of technology shocks differentiated by product and process innovations and by sectoral origin. Product innovations in formerly non-tradable sectors widen the scope in which innovations in one country can be transmitted abroad. One major difference between FDI and trade is the location of production, which induces different international income flows and requires upfront investment in the case of FDI. We show that this has implications for both the current account and the exchange rate. Process innovation in the tradable sector leads to a fall in the terms of trade (ToT) and a real appreciation of the exchange rate, expressed as the ratio between domestic and foreign consumer prices. The opposite sign is due to the Balassa-Samuelson effect. This pattern changes with a total factor productivity (TFP) shock in the non-tradable sector. Now, the ToT increases and the real exchange rate depreciates (aside from a short run appreciation). In the case of product innovations, both ToT and the real exchange rate (RER) behave similarly in both cases. However, the composition of the Current Account (CA) varies. With a process innovation in the export sector, both the trade balance and the primary income balance turn negative while product innovations in the FDI sector make the primary balance positive while the trade balance stays negative. We are especially interested in seeing whether the impulse responses to permanent shocks can tell us something about the reasons for persistent external imbalances in countries like Germany and the United States. For the US we find that product innovations originating from US multinationals, at least qualitatively matches well the negative current account and trade balance and a positive primary income balance. The German/Eurozone CA surplus is less easy to explain by technological factors since in our model all technology shocks are associated with persistent CA deficits. Our model confirms what has been shown in previous studies that the German CA is strongly driven by savings. We add to this the observation that increased savings also shows up in an improved primary income balance, which can indeed be observed for Germany.

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**Zusammenfassung:**

Eine tiefergehende makroökonomische Analyse von ausländischen Direktinvestitionen (FDI), Innovationen und anderen Schlüsselvariablen ist erforderlich, um die Auswirkungen von Technologieschocks, die Transmissionseffekte und die Wirtschaftspolitikpolitik- Perspektiven in modernen offenen Volkswirtschaften besser zu verstehen. Der Bestand an ausländischen Direktinvestitionen (FDI) im Verhältnis zum Gesamtkapitalbestand des Herkunftslandes lag 2019 in zwölf OECD-Ländern über 10 Prozent, darunter Großbritannien und USA. In diesem Papier wird ein Standardmodell mit einem handelbaren und einem nicht handelbaren Sektor um FDI erweitert. Hier definieren wir nicht handelbar in einem weiten Sinne. Der nicht handelbare Sektor umfasst diejenigen Unternehmen, die im handelbaren Sektor angesiedelt sind, aber FDI tätigen, um die mit dem Export verbundenen Kosten zu überwinden; aber es geht auch um Firmen im Dienstleistungssektor, die Dienstleistungen anbieten, die an sich nicht handelbar sind, aber über Tochtergesellschaften international angeboten werden können. Dies betrifft traditionelle Dienstleistungen (z.B. im Einzelhandel), aber auch neuartige digitale Dienstleistungen. Untersucht wird u.a., wie sich die Öffnung Nicht-Handels-Sektors für internationale Transaktionen - via FDI - auf die internationale Übertragung von Technologieschocks und von anhaltenden Nachfrageschocks auswirkt. Betrachtet wird eine breite Palette von Technologieschocks, die sich durch Produkt- und Prozessinnovationen sowie durch die sektorale Herkunft unterscheiden. Produktinnovationen in ehemals nicht handelbaren Sektoren erweitern den Bereich, in dem Innovationen in einem Land ins Ausland übertragen werden können. Ein wesentlicher Unterschied zwischen FDI und Handel ist der Standort der Produktion, der unterschiedliche internationale Einkommensströme induziert und im Falle von FDI Vorabinvestitionen erfordert. Wir zeigen, dass dies Auswirkungen sowohl auf die Leistungsbilanz als auch auf den Wechselkurs hat. Prozessinnovationen im handelbaren Sektor führen zu einem Rückgang der Terms of Trade (ToT) und zu einer realen Aufwertung des Wechselkurses, ausgedrückt als Verhältnis zwischen inländischen und ausländischen Verbraucherpreisen. Das umgekehrte Vorzeichen ist auf den Balassa-Samuelson-Effekt zurückzuführen. Dieses Muster ändert sich mit einem Schock der totalen Faktorproduktivität (TFP) im nichthandelbaren Sektor. Nun steigt die ToT und der reale Wechselkurs wertet ab (abgesehen von einer kurzfristigen Aufwertung). Im Falle von Produktinnovationen verhalten sich sowohl ToT als auch der reale Wechselkurs (RER) in beiden Fällen ähnlich. Allerdings variiert die Zusammensetzung der Leistungsbilanz. Bei einer Prozessinnovation im Exportsektor werden sowohl die Handelsbilanz als auch die Primäreinkommensbilanz negativ, während Produktinnovationen im FDI-Sektor die Primäreinkommensbilanz positiv machen, während die Handelsbilanz negativ bleibt. Uns interessiert besonders, ob die Impulsantworten auf permanente Schocks etwas über die Gründe für die anhaltenden außenwirtschaftlichen Ungleichgewichte in Ländern wie Deutschland und den USA aussagen können. Für die USA stellen wir fest, dass Produktinnovationen, die von multinationalen US-Konzernen ausgehen, zumindest qualitativ gut zu der negativen Leistungsbilanz bzw. zur Handelsbilanz und einem positiven Primäreinkommenssaldo passen. Der deutsche beziehungsweise Eurozonen-Leistungsbilanzüberschuss ist weniger leicht durch technologische Faktoren zu erklären, da in unserem Modell alle Technologieschocks mit anhaltenden Leistungsbilanzdefiziten verbunden sind. Unser Modell bestätigt, was in früheren Studien gezeigt wurde, dass die deutsche Leistungsbilanzposition stark von der Ersparnis getrieben ist. Wir fügen die Beobachtung hinzu, dass sich eine erhöhte Ersparnis auch in einer verbesserten Primäreinkommensbilanz niederschlägt, was für Deutschland tatsächlich zu beobachten ist.

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# 1. Introduction

Foreign direct investment (FDI) activities have increased in recent decades in OECD countries where outward FDI stocks relative to host countries' own capital stock have more than doubled over the period from 1991-2018 (UNCTAD, 2019). Besides trade, FDI investment and FDI-related production now constitutes a relevant part of international transactions in macroeconomic terms. FDI activities are still a rising trend. They are likely to be positively affected by easier communication/digitalization between headquarters and local subsidiaries, they help to overcome trade restrictions and trade in digital services is increasingly likely to take the form of FDI activities (intangible capital can be transferred more easily internationally compared to physical capital).

International mergers and acquisitions (M&As) have played an increasing role over time in OECD countries, but greenfield investment also plays a considerable role (UNCTAD, 2019). With considerable business activities on the part of multinational companies in most OECD countries, China and a few other NICs, there is a need to consider FDI transmission dynamics in many ways, including the impact on trade balances and the net primary balance which can show different reaction patterns. For example, product innovations in the headquarter country could go along with international technology transfers through higher outward FDI which raises the international net profits accruing to the headquarter country (country 1), while the net exports of goods and services of that country could reduce as higher production and sales abroad replace part of the previous imports of country 2 – possibly in contrast to a parallel development of the current account (CA) sub-balances in the context of aggregate demand management through fiscal policy or monetary policy.

Innovation and the international diffusion of knowledge are key elements of multinationals' activities. Empirical analysis suggests (SAMBHARYA/LEE, 2014) that leading MNCs use innovation to organize broader international knowledge diffusion and market conquering efforts which, in turn, reinforce the respective MNC's ability to finance more R&D for the next innovation cycle. From this perspective, product and process innovations are often linked to outward and inward FDI. Innovation-related Schumpeterian macro-modelling thus requires to incorporate FDI into a broader analytical framework.

Open economy macroeconomics has been characterized over time by a high level of analytical investment in DSGE approaches and the areas of trade, portfolio capital flows and total factor productivity as well as a policy focus on monetary policy and fiscal policy, respectively (SMETS/WOUTERS, 2007; see also the QUEST model of the European Commission). The role of foreign direct investment is much less prominent in macro-modelling. Besides a regional DSGE model for Colombia which features the basic inclusion of FDI (MORA MORA/COSTA JUNIOR, 2019), an implicit reference to potential FDI effects in a DSGE model for Ireland (CLANCY/MEROLA, 2016) and an FDI-related DSGE approach looking at selected gross FDI outflow and inflow aspects (KIM/PETROSKY-NADEAU, 2016), there is – to the best of our knowledge - no coverage of foreign direct investment dynamics in DSGE models; indeed, with respect to the macroeconomic perspective presented here, our study presents an attempt to fill this gap.

Associated with FDI activities are cross border capital income flows which figure prominently in the primary income balance within the current account balance. Fluctuations/determinants of the primary income balance have so far not been a major concern in the open economy macro literature. In this paper, we model fluctuations of the primary income balance together with the trade balance by setting up a small 2 country DSGE model which allows for an FDI decision and which considers the role of savings shocks as well as persistent technology shocks.

This paper augments a standard two-country DSGE model with an FDI decision of multinationals in the two countries and ask what implications this has for the transmission of international shocks and what aspects of the data can be better explained by considering FDI decisions explicitly. We are especially interested in the international transmission of permanent demand and supply shocks, and in particular savings shocks as well as process and product innovations emerging in one country. We want to analyze how shock transmission is affected by the presence of multinationals. We will focus on domestic and foreign consumption/welfare, income, real wages, the (real) exchange rate as well as the current account and the balances constituting the current account such as the trade balance, the primary income balance which can be further decomposed into income from FDI and interest income balance. Within our framework, it becomes possible to study the relationship between the individual balances of the current account.

In order to capture various dimensions of FDI activities, we have opted for a two-sector framework. Our two-sector economy can be interpreted in two alternative ways. Firstly (as an extension of the one sector DSGE model) we can think of a former one sector economy where international goods and service transactions took place entirely via imports and exports as currently assumed in the standard model. By introducing a second sector which concentrates entirely on FDI investments (and only exports to the foreign subsidiary), we allow for the fact that certain types of international transaction can better be done by way of FDI investments, for example, in order to avoid high transportation costs (see BLONINGEN, 2005). Thus, introducing a second sector allows to endogenize the choice between exports and FDI at the aggregate country level. Secondly, introducing a second sector - which does not export but is undertaking FDI activities - is a modern extension of the tradeable vs. non-tradeable model and considers that formerly non-tradable activities in service sectors are becoming increasingly international since service providers are setting up foreign subsidiaries. While traditionally the banking, finance and insurance sector had an international presence, nowadays this is increasingly extended to other sectors (e.g., Amazon in the retail sector). Moreover, novel digital services are nowadays provided by multinational companies which serve the foreign market by setting up local subsidiaries (e.g., Google, Facebook, Microsoft). The investment undertaken by these companies is mostly in the form of intangible investment – for example, representing the provision of patents and software.

Sector 1 engages in traditional trade (exports of goods which are produced domestically) and receives export revenues from sales abroad. The second sector engages entirely in FDI, i.e., the domestically developed production technology is used in the foreign country (and operated by foreign workers) to supply the foreign market. FDI entirely replaces trade in sector 2. Instead of export revenues, the domestic producer is receiving rental income and profits/monopoly rents from its foreign operations. Thus, sector 2 is dominated by multinational companies which produce internationally. The only trade is within firm trade. The multinational company

is exporting capital produced within the firm to its foreign affiliate and is charging a price to its foreign affiliate

In order to study the long-term effects of permanent demand and supply shocks we have opted for an OLG structure (following BLANCHARD, 1985) on the household side. In contrast to the infinitely lived household model, assuming finite life times (positive probability of death) determines the long run level of the current account as a function of exogenous fundamental shocks. Moreover, no distinction on preferences for certain types of assets is required and rates of return for all assets are equalized each period.

A model with two distinct sectors concerning international operations allows us to see how (differently) shocks in the two sectors are transmitted. The main contribution of the present paper is as follows: Technology shocks and FDI are added to the standard international macro model. This allows us to study the transmission of shocks via both a trade channel and an FDI channel. One may argue that adding FDI is long overdue for at least two reasons. Firstly, FDI flows have been growing in importance in recent decades. Secondly, the traditional distinction between tradable and non-tradeable goods in international models should be adapted to the observation that certain types of (formerly non-tradable) services which are now provided cross border by FDI-related production activities of multinational companies. Our framework allows us to analyze the domestic and international transmission effects of technology shocks and distinguish between both the type (i.e., process vs. product innovations) and the origin of the innovation (i.e., export sector vs. multinational corporations). The distinction between process innovations and product innovations is crucial. Often, analysis focuses on process innovations in the form of TFP shocks. However, there are contributions in the literature dealing with product innovations in the form of investment-specific technical progress. It is noteworthy that the European Union offers statistical data on both product innovations and process innovations in its bi-annual Community Innovation Survey – see Appendix B - which indeed shows that the ratio of product innovations to process innovations has increased in the European Union in the decade after 2008.

One of our goals is to shed new light on persistent current account imbalances in countries like Germany and the US. Distinguishing between trade and FDI activities and adding the primary income balance as an object of our analysis offers new possibilities to trace the sources of these imbalances. Therefore, we not only look at technology shocks but also at persistent savings shocks, which have played a prominent role for explaining CA imbalances in previous studies (see for example KOLLMANN ET AL., 2015). Finally, since one can observe a trend increase in FDI activities, one can ask which shocks could possibly explain this increase.

The present analysis in the framework of flexible exchange rates is structured as follows: Section 2 provides some descriptive statistics and looks into selected key fields of the literature. Section 3 considers trade, FDI and innovation dynamics in the context of the new DSGE model developed. Section 4 presents the Schumpeterian supply shocks and demand shocks considered (scenarios with transmission aspects). Section 5 suggests some key policy perspectives for the EU/the UK and the United States and also presents ideas for further research.

# 2. Descriptive Statistics and Selected Literature Review

In 1999, US affiliates had average local sales in host countries of 67.4 percent - with a lower share of 58.9 percent in Manufacturing and a higher share of 75.8 percent in Non-manufacturing; sales back to the US were 10.4 percent, sales to unaffiliated parties in other foreign countries was 9.8 percent, sales to related affiliates in other foreign countries reached 12.5 percent (BLONIGEN, 2005). These figures for US multinationals, as well as more recent statistics, show that MNCs' subsidiaries have high sales figures abroad in the respective host country. More recent data for 2018 (see Appendix: Table A1) show that US affiliates' sales back to the US have increased slightly, namely from 10.4 percent in 1999 to 11.9 percent in 2018; in a two-country perspective USA versus Rest of the World FDI-based US sales abroad stood for 88.1 percent in 2018.

Statistics from the 2020 World Investment Report (UNCTAD, 2020) clearly show how strong global FDI inflows and particularly the inward FDI stock has increased over time – the latter rose from $2,196 billion in 1990 to $36,470 billion in 2019 (p. 124). The geographical spread of FDI has increased over time as the number of countries which account for 90 percent of inward FDI indicates – namely, 40 in 2019, compared to just 23 countries in 1990; value-added in foreign affiliates as a percentage of world GDP has increased from a share of 5.6 percent in 1990 to 9.2 percent in 2019 where aspects of international profits shifting and multinational transfer pricing, respectively, might have distorted the UNCTAD figures (Table A2 in Appendix A). If one considers the G20 countries as the dominant group of source and host countries in the world economy – with the G20 standing for about two-thirds of world income – the ratio of value-added in foreign affiliates to G20 national income in 2019 would be about 13.8 percent in 2019. The ratio of royalties and license fee receipts relative to value-added in foreign affiliates increased from 2.3 percent in 1990 to 4.9 percent in 2019 which suggests that the role of technology in multinationals' outward investment has increased over time. This is a trade balance related element of FDI activities – in the case of the US, based on BEA data, with a particularly strong long run increase of revenues from royalties and licensing accruing to the United States.

An analytically crucial aspect of FDI stocks are the associated profits accruing from abroad. They are part of the primary balance which in turn explains to some extent the Current Account (CA).

### *Trade Balance and Primary Balance Dynamics*

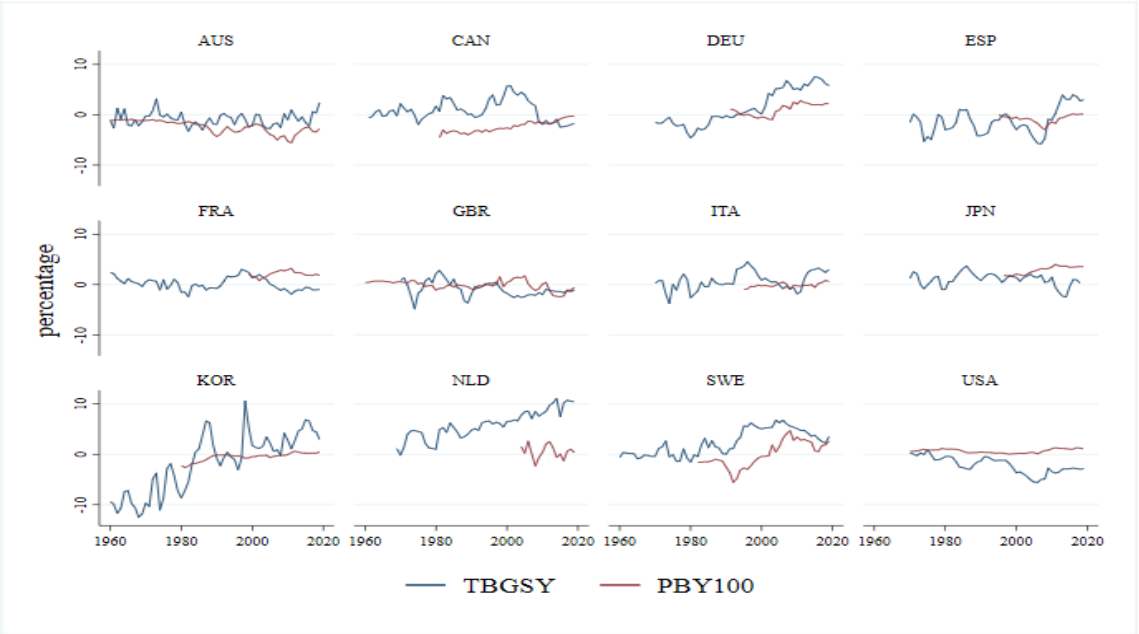
There has not been much debate about the role of the primary balance in the EU (while the debate about the US current account in the Trump Administration has emphasized elements of the primary balance). As regards the current account effects of FDI in catching-up economies, MENCINGER (2008) has emphasized that Eastern European EU accession countries have emphasized policies to attract more FDI inflows and explores consequences for the future evolution of the primary balance

Taking a closer look at the trade balance ratio and the primary balance ratio for ten leading OECD countries, plus the Netherlands and Sweden, shows a rather strong fluctuation of the trade balance ratio and a rather stable primary balance in most countries (see Fig. 1a). The primary balance consists of net portfolio investment profits and net FDI investment profits; short-term portfolio capital flows can react much faster than net FDI profits. The latter reflect

- cumulated inward FDI of host countries; and
- also, to some extent, the respective output gap – that is, the cyclical profit dynamics in the business sector. Higher profit ratios in host countries could, however, lead to both higher profit reinvestment abroad and higher profit transfers to the parent companies in the respective FDI source country.

In most of the selected countries the primary balance ratio seems not to follow a trend, unlike Canada, Germany (DEU), Sweden and Japan. Figures for that ratio are often only available since about 1990, except for Australia, the UK and the United States where such data go back much further. The US shows a rather stable positive primary balance while this balance is rather volatile in Australia and the Netherlands plus Sweden. Data for the UK show that the primary balance ratio can change considerably over time, often in parallel to the trade balance ratio. What links should one expect? One aspect concerns a wave of outward FDI flows which - after some time - should lead to a worsening of the trade balance ratio to the extent that outward FDI raises production abroad which could be a substitute for exports from the headquarter country – at the same time, the primary balance ratio could improve due to rising profits accruing from abroad (relative to the GDP of the source country). However, outward FDI will also raise the foreign national income and GDP, respectively so that imports from country 2 will increase which dampens the trade balance surplus of country 1. Fig. 1b shows changes in both the trade balance ratio and the primary balance ratio and it seems that both balances fluctuate more strongly over time in some smaller OECD countries – such as the Republic of Korea, Sweden and the Netherlands – than in bigger economies; in particular looking at the US.

**Figure 1a: Trade Balance Ratio (Percent of GDP) and Primary Balance Ratio (Percent of GDP) in Selected OECD, Countries 1960-2019**




*Source: Own calculations and representation of data available from the World Bank (Exports (NE.EXP.GNFS.ZS) and Imports (NE.IMP.GNFS.ZS) of goods and services (in % of GDP; annual)) and OECD (Primary Balance and GDP figures from OECD.Stat, Balance of Payments, BPM6)*

**Figure 1b: Change in Trade Balance Ratio (Percent of GDP) and Change in Primary Balance Ratio (Percent of GDP) for Selected OECD Countries, 1990-2019**


*Source: Own calculations and representation of data available from the World Bank (Exports (NE.EXP.GNFS.ZS) and Imports (NE.IMP.GNFS.ZS) of goods and services (in % of GDP; annual)) and OECD (Primary Balance and GDP figures from OECD.Stat, Balance of Payments, BPM6)*

Sectoral aspects of the current account developments are crucial (on the EU, see for example, GEHRINGER, 2013). For the US, there is a useful and well-known paper in the form of the model with tradables and non-tradables from OBSTFELD/ROGOFF (2005) who have emphasized in the empirical analysis that a change of the internal exchange rate – relative price of tradables – has a much stronger effect on the current account than a change of the real exchange rate. Non-tradables and tradables DSGE models have been analyzed by several authors (see, e.g., HIRAKATA/IWASAKI/KAWAI, 2014; RUDOLF/ZURLINDEN, 2013). In the subsequent analysis we go beyond these approaches (and focus on a different angle) in the sense that the non-tradables sector considered is FDI-based which effectively means that the whole economy is internationalized, namely through trade and/or FDI; with FDI-related specific transmission impulses to be considered e.g. for current account adjustment and exchange rate changes. This is, of course, not only important for the US, but for Europe and Japan as well. FROOT/STEIN (1991) consider FDI flows in the context of exhange rate adjustment in a model with imperfect capital markets.

**Selected Literature on Multinational Companies**

There is a large literature which deals with determinants of FDI and the relationship between FDI and trade. In our framework we are largely abstracting from the decision to export or undertake FDI at the firm level. In our framework firms either export (and avoid high costs for setting up foreign affiliates) or they undertake FDI (and avoid high transportation costs). Nevertheless, the technology and preference shocks we are considering have aggregate implications for trade and FDI flows. There is, however a literature which studies FDI dynamics and the determinants of FDI decisions at the firm level more carefully – with some aspects of that literature explaining the relevance of the inclusion of FDI in a macro model. Trade and FDI go together to some extent, partly in the context of a certain sequencing as trade creation and expansion typically follow economic opening up and when trade then has raised per capita income at home and abroad to a critically high level.

- Rising trade between country i and j often creates perceptions of potentially profitable production abroad. Dunning's OLI approach (DUNNING, 1979) argued that ownership specific advantages - typically technology leadership in a specific field - plus internationalization benefits from international intra-company transactions and FDI, respectively, should create the case for outward FDI provided that there are attractive host country locations. CAVES (1982) sketched to some extent a broader FDI theory, followed by the influential contribution of HELPMAN (1984) who simultaneously explained trade and foreign direct investment where the latter played a more important role for the production of technology-intensive goods since fixed R&D costs could effectively be spread internationally through enlarged sales volumes which could be expected by combining ownership specific headquarter advantages of the respective company with production close to the respective national demand side – while exploiting relative international factor endowment differentials. FRANCO (2013) has emphasized – with respect to the US (amongst others) – the role of asset-seeking FDI, which mainly explains firms' decisions to invest abroad as being motivated by a wish or need to gain access to complementary knowledge-intensive assets in OECD countries; there is also the case of FDI from Newly Industrialized Countries whose

multinationals invest abroad in OECD countries seeking complementary assets as well as better market access.

- FEENSTRA/HANSON (2001) argued that globalization was characterized by FDI dynamics which raised the skilled wage ratio in both the source country of FDI and the host country. The latter effect should indeed be expected if outward FDI is at least partly linked to (enhanced) offshoring so that part of value-added in leading industrialized countries would be shifted to production in foreign subsidiaries which to the host countries would naturally bring an international technology transfer (international M&A case/acquisition FDI) or greenfield investment which brings both the technology transfer plus a rise of the capital intensity and hence higher labor productivity and higher real wage rates in the host economies. All this, however, does not explain asset-seeking FDI, where MNCs from high per capita income countries invest in other high per capita income countries (or MNCs from medium per capita income countries investing in high per capita income countries); asset-seeking FDI occurs, for example, in the pharmaceutical sector of the EU and Switzerland where innovative pharmaceutical companies invest in highly innovative US biotech companies – or US companies invest in highly innovative European biotech companies. There is a rather small group of approaches of asset-seeking FDI (see, e.g., MAKINO/LAU/YEH, 2002; IVARSSON/JONSSON, 2003).

- From a modelling perspective one can, of course, not easily include all key aspects of foreign direct investment, rather it is crucial to focus on a few selected aspects which are mainly related to trading costs and the role of R&D. LARCH/ANDERSON/YOTOV (2017) have argued that trade and FDI could be complementary in a framework where domestic investment is physical investment while FDI reflects non-rival technology capital. In a well-known empirical analysis, BLONIGEN/DAVIES/HEAD (2003) indeed show that besides GDP (sum of country i and j and GDP differences squared) trading costs as well as international skill differences matter for foreign direct investment: “affiliate activity between countries decreases as absolute differences in skilled-labor abundance widen”. The smaller the international GDP difference (squared) is and the larger absolute skill differences between parent company and host country, the higher FDI inflows are.

- Thus far, the extent to which there is an optimum aggregate international technology transfer has not been discussed, but at least a rather simple approach will be developed subsequently where the main idea is to maximize real national capital. The simplest approach for maximizing long run - steady-state - per capita consumption would be an enhanced Solow growth model with international technology transfer.

A continuous overlap of trade and FDI in an open economy model with tradable goods seems to be a useful approach to emphasize some key elements of economic reality. Ownership specific assets (read: firm-specific assets) typically play a role for MNCs. There is a broad variety of optional production strategies if one considers the role of positive transportation costs and differences in the fixed cost of creating foreign affiliated firms in various countries (GROSSMAN ET AL., 2006).

There is empirical evidence that FDI will become more important relative to trade when the intra-industry dispersion of productivity is higher, namely as more companies – with higher productivity – are willing to bear the fixed costs of establishing foreign affiliates abroad (HELPMAN ET AL., 2004). There is indeed a broad debate about the drivers of FDI and the main effects (MOLNAR/PAIN/TAGLIONI, 2007), whereby one critical focus is on the impact of FDI and foreign affiliates, respectively, on the price elasticity of labor demand.

HATZIUS (2000) places a focus on the UK and Germany and finds a rising elasticity of manufacturing fixed investment with respect to wage costs: the elasticity is rising over time and particularly in sectors with high FDI levels. SLAUGHTER (2001), with a focus on the US, presents evidence that the price elasticity of the demand for unskilled labor has increased over time in part of manufacturing industries; but not little change was identified for skilled workers. Other studies have rather looked for a link between trade openness and the elasticity of labor demand (e.g., BRUNO ET AL, 2004; SENSES, 2006; OECD, 2007).

The macroeconomic perspective of FDI is crucial with respect to the current account, particularly if one takes into account both product innovations and process innovations. Product innovations – following the logic of the Vernon product cycle (VERNON, 1966) – will improve the current account position for some time, while process innovations in the short term could undermine the current account position unless the price elasticity is fairly high. As regards the link between the inward FDI stock and patent applications, there is evidence for a positive link of MNC activity and patent applications in the EU (JUNGMITTAG/WELFENS, 2020), but the authors could not easily differentiate patents by patents relating to product innovations and process innovations, respectively. However, taking a closer look at product and process innovations and the ratio of inward FDI stock to the host country capital stock, it turns out that product innovations are positively influenced by inward FDI stocks (WELFENS, 2020; in the regression analysis the link between inward FDI stock and process innovations is somewhat weaker).

As regards the international convergence of quality of export products, FDI inflows have been shown to be a significant driver of product quality catching-up in various sectors for a large sample of countries (HENN/PAPAGEORGIOU/ROMERO/SPATAFORA, 2020); the authors have developed a new approach to measure product quality and product innovations, respectively. Direct survey results for product innovations are available only in the European Union with its Community Innovation Survey which differentiates between product innovations and process innovations (see Appendix B). FDI and international technology transfer is a crucial topic: while at first glance one may assume that headquarter company technology can fully be used across the whole network of subsidiaries, it seems that often the availability of skilled workers in the host countries plays a critical role for the breadth of intra-company technology transfer. From this perspective, a standard simple case is to assume full international technology transfer, but the case of partial technology transfer should, in reality, also play a role and, thus, will indeed be considered in subsequent DSGE modeling which includes both trade and FDI.

### *Trade and FDI*

As regards the links between FDI and trade, MUNDELL (1957) has presented arguments for FDI and trade being substitutes. As regards complementary linkages between trade and FDI, there are two basic views in the literature: BLANCHARD (2007), following the earlier view of KOJIMA (1973), has argued that FDI and trade are complements but with opposite trade flow directions when compared to view put forward by KOJIMA (1973). Kojima has shown that there is an increase in exports from the source country to the host country. Such a link could, for example, reflect the fact that outward FDI raises the foreign production potential (via capital accumulation effects and technology transfer in the context of greenfield investment; via technology transfer only if international M&A is considered) and thus real output as well as real national income – and a higher national income will raise the imports from the FDI source country. BLANCHARD (2007) provides evidence that exports from the host country to the source country increased after a rise of FDI inflows. A third view (EKHOLM ET AL., 2007; HANSON ET AL., 2001; MARKUSEN/MASKUS, 2001; BLONIGEN/DAVIES, 2004; IRAWAN, 2017) considers the role of outward FDI stocks as strongly representing opportunities that affiliates export to third countries which is a rather recent development that in part is related to the growth of international ICT production. A broad modeling approach for the international export platform topics has been presented by TINTELNOT (2017). In the subsequent two-country macro model there is, however, no focus on third country perspectives in the context of FDI. As regards key technology aspects – partly linked to FDI – there are additional analytical perspectives to be considered briefly.

### *Product Innovation, Technology Transfer and Technology Spillovers*

Innovation can be split into process innovations – with cost reductions – and product innovations which bring a larger variety of products to the market. In open economies, process innovations could be transferred internationally through a rise of trade in technology-intensive intermediate products as well as through FDI with a direct link to international technology transfer; the latter refers, for example, to the case of subsidiaries abroad using the patent/technology portfolio of the parent company. Moreover, it holds that if FDI is intra-OECD, one may also assume that certain technologies from abroad are transferred back to the parent company if there has been asset-seeking outward FDI which means that multinational companies invest abroad in order to enhance the parent company's technology portfolio. As regards international technology transfer, there has, however, been no distinction with respect to process innovations and product innovations although one may assume that asset-seeking FDI is rather often linked to the aim of enhancing product innovations.

There is both a theoretical debate and an empirical debate about the scope and role of international technology transfer where part of the analytical background is the broad consensus in Economics that markets for intellectual property rights are rather imperfect in market economies (ARROW, 1962). The role of international technology transfers through FDI and multinationals, respectively, is part of the broader FDI debate which also includes relevant transfer for process innovations and product innovations, respectively. This encompasses various international technology transfer fields, including green innovations for example (DUTZ/SHARMA, 2012; GAO ET AL., 2018). There are also complementary aspects, for example between FDI and financial market developments (ALFARO ET AL.,

2004) and, in a broader context, between FDI and productivity growth (e.g. CAVES, 1974). The role of international economic integration and FDI has also been analyzed in the literature, for example within an FDI gravity modelling approach in the context of BREXIT (WELFENS/BAIER, 2018; BAIER/WELFENS, 2019). As regards the role of a new international division of labor in innovation and patenting within MNCs, or in the context of joint patent applications from MNCs - partly with research and development in foreign affiliates –, it seems that "techno-globalization" has played a crucial role since about 1990; with a peak in OECD countries in 2005 (JUNGMITTAG, 2020).

An interesting debate in the FDI-host country literature concerns the question of sectoral technology spillovers as discussed, for example, by BARREL/PAIN (1997) who make a distinction between intra-industry spillovers from foreign firms and inter-industry spillovers: the authors' empirical finding is an estimate which shows a positive effect of inward investment on domestic firms – with a long-run elasticity of labor-capital substitution to be slightly over one-half. PAIN/HUBERT (2002) found for the UK that intersectoral spillovers were slightly higher than intra-sectoral productivity spillovers. The evidence for spillovers from studies by GIRMA ET AL. (2000) and GIRMA/WAKELIN (2000) is weaker than those in BARREL/PAIN (1997) and HUBERT/PAIN (2000). As regards US non-banking FDI in the UK, it was found by PAIN/HUBERT that the share of merchandise exports going to the US – from US affiliates in the UK – has increased over time which suggests specific links between FDI and export dynamics in host countries in the UK; and possibly also in the EU.

### *Current Account Perspectives in a Traditional Perspective and in the Context of FDI and Basic Aspects of Technology Shocks*

Persistent CA imbalances, in particular the German CA surplus, has attracted a lot of attention in the literature (see, for example, KOLLMANN ET AL., 2015). Their study concluded that changes in savings behaviour, related to demographic transitions has been a main driver of the persistent surplus in Germany. A recent Deutsche Bundesbank study (BURSIAN ET AL., 2020) comes to similar conclusions. A number of other factors have also been mentioned, in particular heightened foreign demand for German products (product innovation story).

As regards the analysis of international technology shocks in an open economy macro model there are only a few recent contributions. The role of exogenous productivity shocks is part of the traditional analysis of real exchange rate reactions in open economies. Several authors have exploited sign restrictions (e.g., CORSETTI ET AL., 2014; ENDERS ET AL., 2011) or a combination of short run or long run zero restrictions – in some cases, restrictions on the forecast error variance contribution of technology shocks (LEVCHENKO/PANDALAI-NAYAR, 2020; MIYAMOTO/LAN NGUYEN, 2017, KAMBER ET AL., 2017; NAM/WANG, 2015) to get an identification of exogenous shocks and then estimate the effects in open economies. A number of authors have found that an unanticipated rise of productivity growth brings about a real depreciation (e.g., MIYAMOTO/LAN NGUYEN, 2017), other authors find a real appreciation (ENDERS ET AL., 2011; CORSETTI ET AL., 2014). Several authors have presented different findings for anticipated as opposed to surprise technology shocks – an appreciation follows after an anticipated productivity shock, while a depreciation

follows a surprise productivity shock (LEVCHENKO/PANDALAI-NAYAR, 2020; NAM/WANG, 2015). BURGERT ET AL. (2020) and GIOVANNINI ET AL. (2019) look at the impact of persistent TFP growth differentials which can be seen as a combination of a surprise and anticipated shock. They also find that this shock is associated with a real depreciation. It also is noteworthy that BONDZIE/FOSU/OBU-CANN (2013) have presented a DSGE model for Ghana in which technology shocks – implicitly related to foreign firms - play a crucial role for sectoral expansion (in the oil and gas sector) and for the medium and long run macroeconomic development.

KLEIN/LINNEMANN (2020), referring to some of these and other authors, present evidence – in the context of anticipated and surprise US productivity shocks - for a real appreciation effect of the currency of the innovation country; however, the authors consider solely process innovations (both anticipated and surprise technological innovations – which means a rise of total factor productivity growth for which the empirical part of the innovative Klein-Linnemann approach uses patents as an instrumental variable; whereby patents could represent process as well as product innovations): the authors have considered the effects of technology shocks on exchange rates in an open economy macro model with tradables and non-tradables; however, the technology shocks considered are temporary and not permanent which is at odds with the empirical evidence. The subsequent DSGE analysis with multinational companies/FDI stocks indeed assumes permanent shocks in the form of product innovations and process innovations. International technology diffusion could be a reason for why international technology differentials are temporary. This case will also be considered in our analysis.

# 3. The FDI-Based DSGE Model with Technology Shocks and Demand Shocks

### Households

We adopt an OLG framework (BLANCHARD, 1985) for modelling household savings and investment decisions, since this framework allows to generate steady variations of the current account balance in the case of permanent shocks to savings and technology. The economy is populated by different age cohorts (born in period s). Members of each cohort and across cohorts otherwise have identical preferences and face a constant probability of death ($p = 1 - \gamma$).

Each household in country c (domestic country, foreign country $c^*$) is maximizing an intertemporal utility function over a CES aggregate of domestic and foreign goods. There are four assets, a domestically traded bond $B_t^c$ an internationally traded bond $BW_t^c$, stocks from sector 1 and sector 2 - companies with market value $V_t^1$ and $V_t^2$, respectively. $BW_t^c$ is denominated in foreign currency, where E is the nominal exchange rate (expressed in units of domestic currency per unit of foreign currency ($\Delta E_t > 0$: depreciation of domestic currency). Individuals maximize utility with no concern for their heirs. That is, they write a contract with an insurance company which pays them a premium equal to $pF_{st}$ each period, with the proviso that the insurance company receives the total financial wealth of the household in the case of

death. Due to the positive probability of dying, the effective discount rate exceeds the rate of time preference:

$$U_{s,0}^{c} = \sum_{t=0}^{=}(\beta\gamma)^{t}(log(C_{s,t}^{c})) \quad (1)$$

The budget constraint of the household is given by:

$$\left(B_{st}^{W}E_t + B_{st}^{c} + V_{st}^{c,1} + V_{st}^{c,2} - \left(1 + i_{t-1}^{c^*}\right)B_{st-1}^{W}E_t - (1 + i_{t-1})B_{st-1}^{c} - div_{st-1}^{c,1} - V_{st-1}^{c,1} - div_{st-1}^{c,2} - V_{st-1}^{c,2} - pF_{st}^{c} + P_t^{C}C_{st}^{c} - W_t^{c}(L_{st}^{c,1} + L_{st}^{c,2} + L_{st}^{c,f})\right) \quad (2)$$

Total financial wealth (portfolio):

$$F_{st}^{c} = B_{st}^{W}E_t + B_{st}^{c} + V_{st}^{c,1} + V_{st}^{c,2} \quad (3)$$

The first order conditions w. r. t. financial assets are given by:

$$\frac{\partial \mathcal{L}}{\partial C_{st}^{c}} = \frac{1}{C_{st}^{c}} - \lambda_{st}P_t^{C} = 0 \quad (4)$$

$$\frac{\partial \mathcal{L}}{\partial B_{st}^{c}} = -\lambda_{st} = \beta\lambda_{st+1}(1 + i_t^{c}) = 0 \quad (5)$$

$$\frac{\partial \mathcal{L}}{\partial V_{st}^{c,i}} = -\lambda_{st} = \beta\lambda_{st+1}(1 + div_t^{c,i}) = 0 \quad (6)$$

$$\frac{\partial \mathcal{L}}{\partial B_{st}^{W}} = -(\lambda_{st})E_t + \beta\lambda_{st+1}\left(1 + i_t^{c^*}\right)E_{t+1} = 0 \quad (7)$$

The first order condition for the bond tradable among all domestic households defines a common discount factor across cohorts. The first order conditions for stocks determines the discount factor applied by domestic corporations for maximizing the value of the firm. The first order condition for internationally tradeable bonds, together with the first order condition for domestically tradable bonds determines the interest parity condition

$$(1 + i_t^{c}) = \left(1 + i_t^{c^*}\right)(E_{t+1}/E_t) \quad (8)$$

Given the medium term focus of our analysis and in order to simplify the discussion of transmission channels of the diverse shocks we assume inelastic labor supply.

**Corporate Sector**

Sector 1: Firms engage in traditional trade and do not undertake FDI.

There are $n^{d}$ domestic firms and $n^{f}$ foreign firms active in sector 1. Each firm produces a variety of domestic and foreign goods, respectively. The number of varieties is exogenous; however, we allow for exogenous product innovation, in the form of an increase in the number of varieties. This is associated with new plants, producing these additional varieties. Firm *i* in sector 1 faces a domestic and a foreign demand curve and serves both the domestic and foreign

markets with products produced at home. The firm is monopolistically competitive and faces price elasticity $\varepsilon_1^c$ in the domestic market and $\varepsilon_1^{c^*}$ in the foreign market. In order to simplify, we assume that the firm faces the same price elasticity in domestic and foreign markets, i.e. the firm charges the same mark up in the domestic and foreign market. There is domestic cost pricing in export markets.

**Demand for variety i**

$$Y_{i,1}^c = \left(\frac{PC_1^c}{P_{i1}^c}\right)^{\varepsilon_1^c} Y_1^{D,c} + \left(\frac{PC_1^{c^*}}{P_{i1}^c/E}\right)^{\varepsilon_2^{c^*}} Y_1^{D,c^*} \tag{9}$$

The elasticity of substitution between different varieties in sector 1 determines the mark up $\mu_1^c = \frac{1}{\varepsilon_1^c}$

**Supply**

Production function with capital and labor as inputs:

$$Y_{i1}^c = A_1^c {L_{i1}^c}^{\alpha} {K_{i1}^c}^{1-\alpha} \tag{10}$$

Aggregate production of sector 1:

$$Y_1^c = n_1^d Y_{i1}^c \tag{11}$$

$A_1^c$ : Total Factor Productivity (TFP) - All firms operating in sector 1 have the same country-specific level of TFP. All firms pay the country-specific wage, i.e. we assume no sector specific labor supply and full mobility of labor across sectors. Production is undertaken by corporations owned by domestic households. The corporation maximizes the present discounted value (PDV) of current and future expected cash flows using the discount factor of the domestic owner

$$\begin{aligned} Max\ PDV_{1,0}^c = & \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^k \left[P_{1t}^c(Y_{1t}^c) Y_{1t}^c - W_t^c L_{1t}^c - P_{1t}^{C^c} I_{1t}^c\right] \\ & - \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^k \lambda_{1t}^c \left[Y_{1t}^c - (A_{1t}^c L_{1t}^c)^{\alpha} {K_{1t}^c}^{1-\alpha}\right] \\ & - \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^k q_{1t}^c [K_{1t}^c - I_{1t}^c - (1-\delta) K_{1t-1}^c] \end{aligned} \tag{12}$$

The first order conditions of this maximization problem yield standard demand equations for capital and labor. The firm equates the marginal product of capital (adjusted for the mark up) to capital cost:

$$\left(1-\frac{1}{\varepsilon_1}\right) Y_{K1t}^{c} = \frac{P_t^{C^c}}{P_{1t}^{c}} (i_t^{c} + \delta - \pi_{t+1}^{C}) \tag{13}$$

Capital cost for the firm declines if the investment goods price declines in period t relative to the product price in sector 1. It increases with the domestic nominal interest rate and it declines with the expected inflation rate for investment goods. Labor demand is determined by equating the marginal value product of labor to the real wage costs

$$\left(1-\frac{1}{\varepsilon_1^{c}}\right) Y_{L1t}^{c} = \frac{W_t^{c}}{P_{1t}^{c}} \tag{14}$$

Equilibrium condition for sector 1 goods (domestic economy):

$$Y_{1t}^{c} = C_{1t}^{c} + C_{1t}^{c^*} + I_{11t}^{c} + I_{12t}^{c^*} + I_{1f,t}^{c} \tag{15}$$

Sector 1 output is sold to domestic and foreign consumers and to domestic and foreign firms in sector 1 and sector 2 as well as to domestic FDI producers (with $I_{i,s}^{c},\ i = good\ 1,2;\ \ s = sector\ 1,2,f$)

Sector 2: Firms engage in FDI and do not export.

Firm *i* in sector 2 faces a domestic and a foreign demand curve but serves the domestic and foreign market with products produced both at home and abroad, respectively. The firm is monopolistically competitive and faces price elasticity $\varepsilon_2^{c}$ and $\varepsilon_{fdi}^{c}$. Here we also restrict elasticities to be identical.

**Demand**

$$Y_{i,2}^{c} = \left(\frac{PC_2^{c}}{P_{i2}^{c}}\right)^{\varepsilon_2^{c}} Y_2^{D,c} + \left(\frac{PC_{fdi}^{c^*}}{P_{ifdi}^{c}}\right)^{\varepsilon_f^{c}} Y_f^{D,c^*} \tag{16}$$

**Supply**

Multinational company *i* produces at home and abroad (FDI) using an identical production technology:

$$Y_{ij}^{c} = A_{1j}^{c} {L_{ij}^{c}}^{\alpha} {K_{ij}^{c}}^{1-\alpha}, \quad j = 2, f \tag{17}$$

The corporations in sector 2 are also owned by the domestic households. The MNC maximizes the PDV of current and future expected cash flows using the discount factor of the domestic owner. In this case, the multinational corporation is deciding about domestic and foreign production, domestic and foreign investment and domestic and foreign employment. The optimization is subject to a technological constraint and a capital accumulation constraint.

$$\begin{aligned}
Max\ PDV_{2,0}^{c} = & \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^{k} \left[P_{2t}^{c}(Y_{2t}^{c}) Y_{2t}^{c} - W_{t}^{c} L_{2t}^{c} - P_{2t}^{c^{c}} I_{2t}^{c}\right] \\
& - \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^{k} \lambda_{2t}^{c} \left[Y_{2t}^{c} - (A_{2t}^{c} L_{2t}^{c})^{\alpha} {K_{2t}^{c}}^{1-\alpha}\right] \\
& - \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^{k} q_{2t}^{c} [K_{2t}^{c} - I_{2t}^{c} - (1-\delta) K_{2t-1}^{c}] \\
& + \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^{k} \left[P_{ft}^{c^{*}}(Y_{ft}^{c^{*}}) Y_{ft}^{c^{*}} - W_{t}^{c^{*}} L_{ft}^{c^{*}} - P_{ft}^{c^{c^{*}}} I_{ft}^{c^{*}}\right] E_{t} \\
& - \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^{k} \lambda_{ft}^{c^{*}} \left[Y_{ft}^{c^{*}} - (A_{2t}^{c^{*}} L_{ft}^{c^{*}})^{\alpha} {K_{ft}^{c^{*}}}^{1-\alpha}\right] \\
& - \sum_{t=0}^{\infty} \prod_{k=0}^{t} \left(\frac{1}{1+i_{t+k}}\right)^{k} q_{ft}^{c^{*}} [K_{ft}^{c^{*}} - I_{ft}^{c^{*}} - (1-\delta) K_{ft-1}^{c^{*}}]
\end{aligned} \tag{18}$$

First order conditions with respect to output, investment, capital and labor yields standard optimality conditions for capital and labor in the case of domestic and FDI production.

Domestic:

The firm equates the marginal product of capital (adjusted for the mark up) to capital cost

$$\left(1 - \frac{1}{\varepsilon_{2}^{c}}\right) Y_{K2t}^{c} = \frac{P_{t}^{c^{c}}}{P_{2t}^{c}} (i_{t}^{c} + \delta - \pi_{t+1}^{C}) \tag{19}$$

And the marginal product of labor to the real wage cost

$$\left(1 - \frac{1}{\varepsilon_{2}^{c}}\right) Y_{L2t}^{c} = \frac{W_{t}^{c}}{P_{t2}^{c}} \tag{20}$$

**FDI:**

The firm equates the marginal product of capital (adjusted for the mark up) to capital cost adjusted for expected changes in the exchange rate:

$$\left(1-\frac{1}{\varepsilon_f^{c^*}}\right)Y_{Kft}^{c^*}=\frac{P_t^{Cc^*}}{P_{ft}^{c^*}}(i_t^c+\delta-\pi_{ft+1}^{C^*}-\Delta E_{t+1}/E_t) \tag{21}$$

since the firm considers that distributed profits are paid in domestic currency to shareholders. Labour demand is given by:

$$\left(1-\frac{1}{\varepsilon_f^{c^*}}\right)Y_{Kft}^{c^*}=\frac{W_t^{c^*}}{P_{tf}^{c^*}} \tag{22}$$

Equilibrium condition for sector 2 goods (domestic economy):

$$Y_{2t}^c=C_{2t}^c+I_{21t}^c+I_{22t}^c+I_{2f,t}^c+I_{2f,t}^{c^*} \tag{23}$$

Sector 2 output produced domestically is sold to domestic consumers and to domestic firms in sector 1 and sector 2 as well as to domestic FDI producers (with $I_{2,s}^c$, $2=good\ produced\ by\ sector\ 22;\ \ s=sector\ 1,2,f$). The domestic sector is also supplying the foreign affiliate with investment goods.

Equilibrium conditions sector 2 (foreign affiliate):

$$Y_{ft}^{c^*}=C_{ft}^{c^*}+I_{f1t}^{c^*}+I_{f2t}^{c^*} \tag{24}$$

The foreign affiliates of sector 2 multinationals supply foreign consumers and firms operating in the sector 1 and 2 of the foreign economy. The domestic sector is also supplying the foreign affiliate with investment goods.

**Current account/Net foreign assets**

The current account consists of the trade balance in goods and services, and the income balance. Here we concentrate on the primary income and we break it down into income from direct investment on the one hand and income from financial investment (portfolio investment, loans

and deposits). Henceforth we will call the net income from direct investment primary income balance and the net income from financial investment, interest income balance.

*Imports of household consumption goods and services and firm investment goods.* Domestic firms (and households) have a domestic bias concerning the origin of investment goods (related to the domestic import share) while FDI producers mimic the investment composition of the country of origin. It is assumed that the composition of consumption and investment of domestic/foreign households and domestic/foreign firms in sector 1 and 2 is identical.

Let $Z_t^c = (C_t^c, I_{1t}^c, I_{2t}^c)$

$$Z_t^c = \left[ s^{d\frac{1}{\sigma}} Z_t^{c,D\frac{\sigma-1}{\sigma}} + s^{m\frac{1}{\sigma}} Z_t^{c,M\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{25}$$

$$Z_t^{c,D} = \left[ s^{d1\frac{1}{\sigma^d}} Z_t^{c,D1\frac{\sigma^d-1}{\sigma^d}} + s^{d2\frac{1}{\sigma^d}} Z_t^{c,D2\frac{\sigma^d-1}{\sigma^d}} \right]^{\frac{\sigma^d}{\sigma^d-1}} \tag{26}$$

$$Z_t^{c,M} = \left[ s^{m\frac{1}{\sigma^m}} Z_t^{c,M1\frac{\sigma^m-1}{\sigma^m}} + s^{fdi\frac{1}{\sigma^m}} FDI_t^{c,FDI\frac{\sigma^m-1}{\sigma^m}} \right]^{\frac{\sigma^m}{\sigma^m-1}} \tag{27}$$

It is further assumed that the foreign subsidiary of the domestic multinational has the identical structure of investment as the parent company.

$$I_{ft}^c = \left[ s^{d\frac{1}{\sigma}} I_{ft}^{c,M\frac{\sigma-1}{\sigma}} + s^{m\frac{1}{\sigma}} I_{ft}^{c,D\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{28}$$

$$I_{ft}^{c,M} = \left[ s^{d1\frac{1}{\sigma^d}} I_{ft}^{c,M1\frac{\sigma^d-1}{\sigma^d}} + s^{d2\frac{1}{\sigma^d}} I_{ft}^{c,M2\frac{\sigma^d-1}{\sigma^d}} \right]^{\frac{\sigma^d}{\sigma^d-1}} \tag{29}$$

$$I_{ft}^{c,D} = \left[ s^{m\frac{1}{\sigma^m}} I_{ft}^{c,D1\frac{\sigma^m-1}{\sigma^m}} + s^{fdi\frac{1}{\sigma^m}} I_{ft}^{c,D2\frac{\sigma^m-1}{\sigma^m}} \right]^{\frac{\sigma^m}{\sigma^m-1}} \tag{30}$$

While households and firms operating in sector 1 and sector 2 in the home country have a home bias concerning consumption and investment, FDI subsidiaries operating in a specific country have a foreign bias.

The local FDI producer exactly mimics the investment pattern of sector 2 in the source country and is importing a large fraction of investment goods from sector 1 and sector 2 of the source country and is only demanding a small part of its investment from the local sector 1 and 2.

Since it mirrors the investment pattern of the foreign mother company, it does not demand investment goods produced locally by itself, but uses investment goods produced by the local sector 2. Therefore, the domestic FDI producer is also demanding investment goods from domestic sector 2. This can be physical investment goods produced in sector 2 but it can also be licence fees for intellectual property which the foreign affiliate has to pay to the parent company. Note, these payments are not part of FDI profit but are an export of services of the parent company to the foreign affiliate and appear in the trade balance.

$$TB_t^c = (P_{t1}^c X_{t1}^c - P_{t1}^{c^*} E_t M_{1t}^c) + (P_{t2}^c X_{t2}^c - P_{t2}^{c^*} E_t M_{2t}^c) \tag{31}$$

All international financial investments are summarized by an internationally tradable bond (denominated in foreign currency).

$$IntY_t^c = i_{t-1}^{c^*} BW_{t-1}^c E_t \tag{32}$$

Net primary income is equal to distributed profits of foreign subsidiaries (revenue minus wage costs minus current investment expenditures):

$$PRB_t^c = (PROFIT_{t,fdi}^c E_t - PROFIT_{t,fdi}^{c^*}) \tag{33}$$

The current account balance:

$$CA_t^c = TB_t^c + IntY_t^c + PRB_t^c \tag{34}$$

The current account can be rewritten as an asset accumulation equation for the internationally tradable bond $BW_t^c$

$$\begin{aligned} BW_t^c E_t = {} & \left(1 + i_{t-1}^{c^*}\right) BW_{t-1}^c E_t + P_{t1}^c X_{t1}^c - P_{t1}^{c^*} E_t M_{1t}^c + P_{t2}^c X_{t2}^c \\ & - P_{t2}^{c^*} E_t M_{2t}^c + PROFIT_{t,fdi}^c E_t - PROFIT_{t,fdi}^{c^*} \end{aligned} \tag{35}$$

Note, a more extensive formulation would include the value the foreign capital stock of multinationals:

$$\begin{aligned} & BW_t^c E_t + V_{ft}^c - V_{ft}^{c^*} \\ & = \left(1 + i_{t-1}^{c^*}\right) BW_{t-1}^c E_t + P_{t1}^c X_{t1}^c - P_{t1}^{c^*} E_t M_{1t}^c + P_{t2}^c X_{t2}^c - P_{t2}^{c^*} E_t M_{2t}^c \\ & + PROFIT_{t,fdi}^c E_t + V_{ft-1}^c - PROFIT_{t,fdi}^{c^*} - V_{ft-1}^{c^*} \end{aligned} \tag{36}$$

But in each period the stock of existing assets in period t and the stock of assets from the previous period are valued at the current price (and number of shares remain constant), thus we have:

$$V_{ft}^c = q_{ft}^c S_{ft} \text{ and } V_{ft-1}^c = q_{ft}^c S_{ft-1} \text{ and } S_{ft} = S_{ft-1} \Rightarrow V_{ft}^c = V_{ft-1}^c \tag{37}$$

Sustainability requires that the value of net foreign debt is equal to the present discounted value of the trade surplus and net primary income. Iterating the above equation forward yields:

$$-\left(1+i_{t-1}^{c^*}\right)BW_{-1}^{c}E_0 = \sum_{t=0}^{\infty}\prod_{k=0}^{t}\left(\frac{1}{1+i_{t+k}}\right)^k TB_t^c + \sum_{t=0}^{\infty}\prod_{k=0}^{t}\left(\frac{1}{1+i_{t+k}}\right)^k PROFIT_{f,t}^{c}E_t - \sum_{t=0}^{\infty}\prod_{k=0}^{t}\left(\frac{1}{1+i_{t+k}}\right)^k PROFIT_{f,t}^{c^*} \quad (38)$$

Since the PDV of current and future (distributed) profits is equal to the market value of FDI capital:

$$V_{f,0}^{c} = \sum_{t=0}^{\infty}\prod_{k=0}^{t}\left(\frac{1}{1+i_{t+k}}\right)^k PROFIT_{fdi,t}^{c}E_t \quad (39)$$

$$V_{f,0}^{c^*} = \sum_{t=0}^{\infty}\prod_{k=0}^{t}\left(\frac{1}{1+i_{t+k}}\right)^k PROFIT_{f,t}^{c^*} \quad (40)$$

We can also express the sustainability condition value of net foreign asset (where FDI assets are evaluated at their current market price) as equal to (restricts) the PDV of future trade deficits:

$$\left(1+i_{t-1}^{c^*}\right)BW_{-1}^{c}E_0 + V_{f,0}^{c} - V_{f,0}^{c^*} = -\sum_{t=0}^{\infty}\prod_{k=0}^{t}\left(\frac{1}{1+i_{t+k}}\right)^k TB_t^c \quad (41)$$

**Definitions**

Note: We normalize the (ideal) consumer price deflator in country c and c* to one:

$$P^c = P^{c^*} = 1 \quad (42)$$

This normalization holds for the flexible price case. In this case, money is completely neutral. In the Keynesian case (with price adjustment frictions) we replace this normalization with a standard central bank policy rule (e.g., a Taylor rule). In the Keynesian case monetary policy has real effects in the short run.

GDP (at base year prices): Sum of value added from the 3 domestic production sectors:

$$P_{t_0 1}^{c}Y_{t1}^{c} + P_{t_0 2}^{c}Y_{t2}^{c} + P_{t_0 2,fdi}^{c}Y_{t2,f}^{c} \quad (43)$$

This is equal to total income generated in the three sectors since the sum of wage income, rental income from capital (including depreciation) and profit income is equal to value added/revenue.

GNP (at base year prices): Total income received by country c households:

$$P^c_{t_0 1} Y^c_{t1} + P^c_{t_0 2} Y^c_{t2} + W^c_{t_0 2,fdi} L^c_{t2,f} + \left(PROFIT^c_{t,f} E_t - PROFIT^{c^*}_{t,f}\right) + i^{c^*}_{t-1} BW^c_{t-1} E_t \quad (44)$$

This is equal to sector 1 and sector 2 revenues earned in country c plus wage income paid by foreign subsidiaries, plus distributed profits received minus distributed profits paid plus net foreign interest income.

## Data and Calibration/Parametrization

This section shows some basic stylized facts about exports and imports, FDI as well as CA, trade and primary income balances

### *Exports Versus Affiliates' Value Added in a Transatlantic Perspective*

If one considers the relative size of UK exports of goods and services and the size of US affiliates' value-added in Germany and the UK (see Table 1) – and in a similar way the German and UK exports vs. FDI-based output in the US – one can see that value-added of US affiliates in the UK exceeded in 2000-2018 the value of US exports and services to the UK. Since US exports contain some intermediate inputs from abroad, the US export ratio based on value-added exports would be even slightly smaller than the figure for the exports relative to the UK GDP (note that it is well known that EU countries' intermediate imports in exports to the US are higher – expressed as a share of "gross exports" – than the share of intermediate foreign products in US exports (WELFENS/IRAWAN, 2014)). The same holds for the US export ratio for Germany as compared to US affiliates' value-added in Germany except for the year 2019. US exports are smaller than US affiliates' value added. UK exports to the US and UK affiliates value-added in the US are roughly equal – only in 2010 UK exports were slightly above the British affiliates value-added in the US. As regards Germany, German affiliates in the US recorded a higher value-added than Germany's exports to the US; with a narrowing to both indicators over time.

**Table 1: Exports of Goods and Services and Affiliates Value-Added for the US, Germany, the UK, Canada, France, Italy, Japan in a Transatlantic and US-Japan Perspective, 1990-2018**

| | **Exports in Goods and Services by Partners in the percentage of GDP (GE is Germany)** | | | | | **Value Added of Affiliates to GDP**[1] | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | | **(5)** | **(6)** | **(7)** | **(8)** |
| | **US EX to UK / UK GDP** | ***US EX to GE / GE GDP*** | *UK EX to US / US GDP* | GE EX to US / US GDP | | **US Affiliates in the UK / UK GDP** | ***US Affiliates in the GE / GE GDP*** | *UK Affiliates in the US / US GDP* | GE Affiliates in the US / US GDP |
| **1991** | **1.93%** | ***1.14%*** | *0.30%* | 0.42% | **1991** | - | - | - | - |
| **2000** | **4.46%** | ***2.34%*** | *0.69%* | 0.74% | **2000** | **6.69%** | ***3.10%*** | *0.54%* | 1.06% |
| **2010** | **4.24%** | ***2.21%*** | *0.64%* | 0.77% | **2010** | **6.19%** | ***2.52%*** | *0.78%* | 0.51% |
| **2019** | **5.22%** | ***2.50%*** | *0.59%* | 0.76% | **2018** | **5.92%** | ***2.14%*** | *0.82%* | 0.62% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **US EX to CA / CA GDP** | ***US EX to FR / FR GDP*** | *CA EX to US / US GDP* | FR EX to US / US GDP | | **US Affiliates in CA / CA GDP** | ***US Affiliates in FR / FR GDP*** | *CA Affiliates in US / US GDP* | FR Affiliates in the US / US GDP |
| **1991** | **13.95%** | ***1.21%*** | *1.48%* | 0.22% | **1991** | - | - | - | - |
| **2000** | **27.51%** | ***2.26%*** | *2.47%* | 0.40% | **2000** | **9.90%** | ***2.64%*** | *0.36%* | 0.38% |
| **2010** | **19.06%** | ***1.71%*** | *2.07%* | 0.38% | **2010** | **8.09%** | ***1.90%*** | *0.38%* | 0.40% |
| **2019** | **20.80%** | ***2.22%*** | *1.70%* | 0.37% | **2018** | **7.84%** | ***1.88%*** | *0.60%* | 0.44% |
| | | | | | | | | | |
| | **US EX to JP / JP GDP** | ***US EX to IT / IT GDP*** | *JP EX to US / US GDP* | IT EX to US / US GDP | | **US Affiliates in JP / JP GDP** | ***US Affiliates in IT / IT GDP*** | *JP Affiliates in the US / US GDP* | IT Affiliates in the US / US GDP |
| **1991** | **1.34%** | ***0.69%*** | *1.49%* | 0.19% | **1991** | - | - | - | - |
| **2000** | **2.08%** | ***1.46%*** | *1.61%* | 0.31% | **2000** | **0.74%** | ***1.82%*** | *0.62%* | 0.05% |
| **2010** | **1.84%** | ***1.07%*** | *0.99%* | 0.25% | **2010** | **0.84%** | ***1.33%*** | *0.54%* | 0.06% |
| **2019** | **2.46%** | ***1.67%*** | *0.84%* | 0.32% | **2018** | **1.02%** | ***1.57%*** | *0.78%* | 0.05% |

*Note: [1] Value added (Gross product), All Majority-owned Foreign Affiliates (2010-2018), Majority-owned Nonbank Foreign Affiliates (2000)*
*Source: Own calculations and representation of data available from the BEA, US Census, WDI*

Exports of the US to Canada (CA in Table 4) are much higher than US affiliates value-added in Canada; however, US exports to Canada are likely to incorporate considerable intermediate inputs from Canada so that the export-FDI value-added gap should be smaller than indicated in the above table. US exports to France were rather similar to US affiliates' value-added in the period 1991-2019. US exports to Japan were generally higher than US affiliates' value-

added in Japan, possibly because opportunities for US international mergers and acquisitions in Japan are quite limited given the strong "Kereitsu groups" which allow large Japanese companies to fend off international takeovers through networked actions of industrial groups. Italian exports to the US were generally higher than Italian affiliates' value-added in the US – this is largely reflective of the weak role of Italian multinationals in Italy. The overall picture for major EU countries suggests that FDI-based value-added in the US is at least as large as exports from the respective headquarter country. As regards the overall picture for OECD countries, there is a considerable lack of data compared to the US case which, however, already gives an interesting picture.

**The choice of parameters**

We consider a two-country model of the world economy with countries of equal size. The two countries are identical concerning preference and technology parameters. The economy is initially in a steady state with a zero current account balance. To be realistic, we allow for home bias, i.e. the share parameters in CES aggregates for C and I are consistent with an import share of 20 percent. The share parameters in the CES aggregate for imports and FDI production are consistent with a share of FDI production of 12 percent.

Concerning savings, we see the rate of time preference to 0.01 and the household planning horizon to 40 years. Firms in all sectors use a Cobb Douglas technology with output elasticity for capital and labour of 0.4 and 0.6. The depreciation rate on capital is set to 5 percent. We set the adjustment cost parameter to 2.5 which ensures that investment is between 2 and 3 times as volatile as GDP. There is monopolistic competition with a mark-up of 10 percent.

Since we are interested in permanent shocks, we set the shock persistence to 1 which is consistent with the random walk nature of TFP shocks. Similarly, we consider permanent shocks for the rate of time preference, which is consistent with savings dynamics as for example induced by demographic changes.

The elasticity of substitution between domestic and foreign tradables is important for the adjustment of the exchange rate. Here, we follow the recent literature and set it to 2. This is based on empirical evidence provided by BOEHM ET AL. (2020). These values have also been used by KLEIN/LINNEMANN (2020) and BENIGNO/THOENISSEN (2008). Concerning the elasticity of substitution (EoS) between sector 1and sector 2 goods, we assume a lower value (1.25), but not the usual value of 0.5 often used for characterizing the EoS between tradables and non-tradables. This is because sector 1 and sector 2 in our model are not strictly identical to tradable (T) and non-tradable (NT) sectors. The two sectors we are studying may provide goods which are highly substitutable (a car manufacturer who is both exporting and setting up local production - in the case large countries, this pattern often refers to the role of transportation costs). In the second interpretation, the elasticity between sector 1 and sector 2 could be small (goods vs. services), but the elasticity of substitution between the local FDI producer and the local service sector is likely to be high (see also Annex .

Moreover, a value larger than 1 more easily captures the stylized fact of a rising FDI share (e.g., related to a higher technology growth in sector 2 (multinationals)). We assume the same

EoS between imported goods and goods produced by FDI producers, since this mirrors the EoS between sector 1 and sector 2 goods.

# 4. Scenarios: Macroeconomic Shocks and New Transmission Aspects

In modern economies, the usual distinction between tradeable manufacturing and non-tradeable services with positive technology growth in the former sector and zero innovation in the latter no longer holds (see, for example van Ark et al (2008)) and technology transmission of non-tradeable technology shocks becomes possible via FDI activities. Our model allows for this additional transmission channel. In our extended version of a T-N model, non-tradability can be overcome by FDI.

This considerably widens the channels in which technology shocks are transmitted to the Rest of the World (RoW) (see also BALTABAEV, 2014). While in the classical T-N model the shock originates only in the T sector and can transmit to the RoW via lower prices for either intermediate products or investment goods imported from abroad. In our model, technology shocks originating in the N sector are transmitted via two channels to the RoW. A first direct channel is the technology adoption by the foreign subsidiary and the second channel is via the input linkages between the foreign subsidiary and the tradable and non-tradable sector in the economy where the subsidiary is located. In our model, this link occurs because local firms are buying investment goods from all domestic producers (including foreign subsidiaries) in addition to importing tradeable goods. Note also that technology adoption by the foreign subsidiary not only consists of a direct effect from a positive TFP shock in the parent company but also transmits via the technology transmission to other sectors in the foreign economy leading to lower investment goods prices from which the foreign subsidiary benefits more strongly because of a "foreign bias" in its investment good composition. Via this link the foreign subsidiary also benefits from technology improvement in the foreign tradable sector and, by offering not only consumer but also investment goods to all sectors in the domestic economy, opens a further channel for technology transmission.

In studies of international technology transmission in the RBC/DSGE literature (e.g. Backus et al. 1995), the focus is usually on process innovations in the form of TFP shocks. Less attention is given to product innovations, which play an important role in the endogenous growth literature and are likely to be important empirically. We study product innovations in consumption and investment aggregates originating in either the tradeable or non-tradeable sector.

In studying technology transmissions, the RBC/DSGE literature often looks at stationary technology shocks, while there is overwhelming evidence that technology shocks have a random walk component. Therefore, we concentrate on (non-anticipated) permanent shifts in the level of technology for both product and process innovations.

***Diffusion:***

Permanent technology shocks will not necessarily lead to permanent level differentials between the domestic and the foreign economy, if there is technology diffusion. Diffusion is likely to be important empirically and the comparison between diffusion and no diffusion illuminates the various transmission channels, therefore we will also show results with diffusion. In this case we assume that the technology difference has a half live of 15 years. This corresponds roughly to temporary shock with autocorrelation coefficient of 0.95. Some evidence on positive innovation effects for domestic firms is provided by DACHS, 2020.

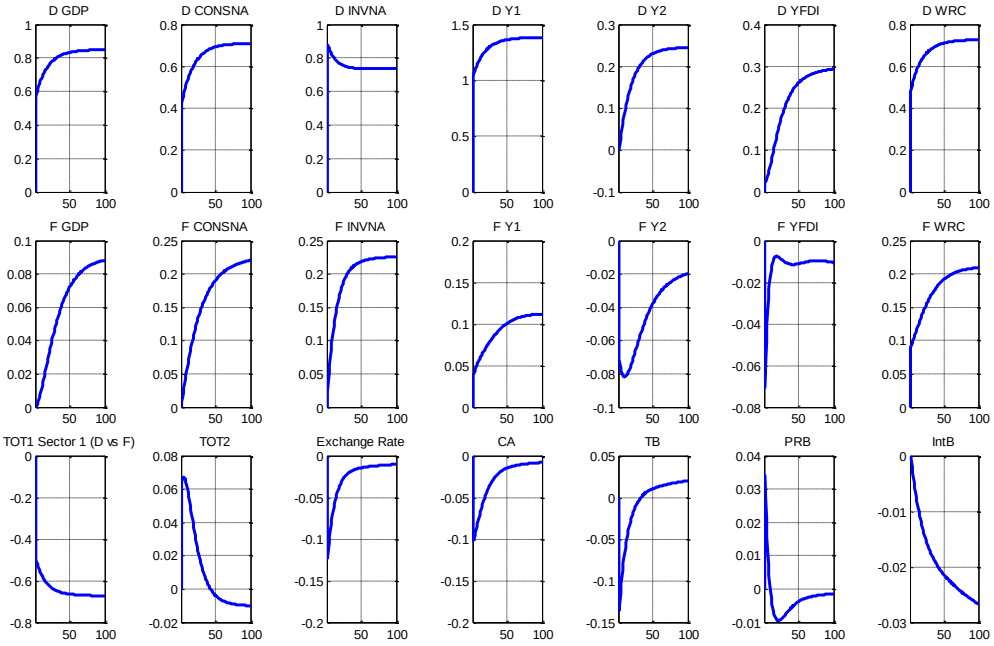
**Table 2: Shocks Related to the Scenarios**

| | | |
|---|---|---|
| **Process innovation: (no diffusion)** | | |
| TFP-1A: Permanent increase of domestic TFP in sector 1 | TFP-2A: Permanent increase of domestic TFP in sector 2 and TFP by the foreign affiliate | Joint: TFP-1A and TFP-2A |
| **Process innovation: (with diffusion)** | | |
| TFP-1B: TFP-1A with diffusion of TFP to foreign sector 1 | TFP-2B: TFP-2B with diffusion of TFP to foreign sector 2 | |
| **Product innovation: (no diffusion)** | | |
| PI-1A: Permanent increase share of sector 1 goods by domestic investors and consumers and permanent increase of imports from sector one of households and firms in the foreign economy. | PI-2A: Permanent increase share of sector 2 goods by domestic investors and consumers and permanent increase of the share of FDI production in consumption and investment in the foreign economy. | Joint: PI-1A and PI-2A |
| **Product innovation: (with diffusion)** | | |
| | | |
| PI-1B: PI-1A with diffusion to sector 1. | PI-2B: PI-2A with diffusion to sector 2. | |
| **Savings:** | | |
| Permanent reduction in the rate of time preference | | |

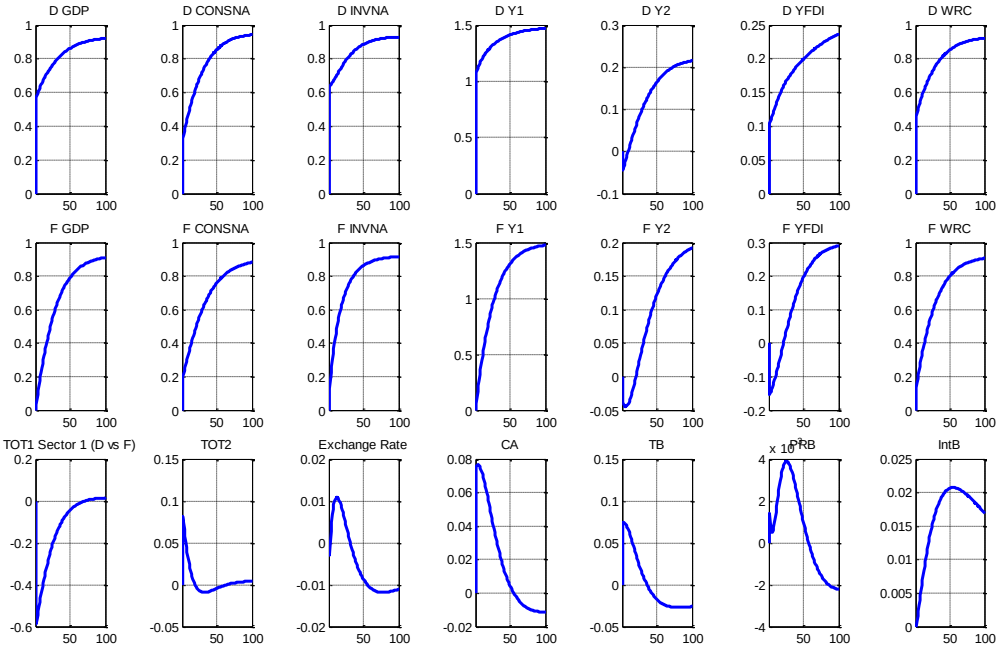
*Source: Own representation*

## Process Innovation

### Figure 2a: Permanent increase of TFP in sector 1 (no diffusion)




### Figure 2b: Permanent increase of TFP in sector 1 (with diffusion)




*D: Domestic; F: Foreign*

*GDP: Real GDP; ConsNA: Private Consumption; INVNA: Total Investment; Y1: Output Sector 1; Y2: Domestic Output Sector 2; YFDI: Foreign Output Sector 2; WRC: Real Consumption Wage;*

*TOT Sector 1: Price of Sector 1 output relative to import price of sector 1; TOT Sector 2:Output Price of foreign Subsidiary of Sector 2 relative to the Price of foreign Sector 2; Exchange Rate: Real Exchange Rate* ($E_t PC_t^{c^*}/PC_t^c$)*; CA: Current Account; TB: Trade Balance; PRB: Primary Income Balance; IntB: Interest Income Balance*
*Source: Own representation*

### *No Diffusion*

TFP Shock in the export industry has positive GDP and spillover effects. In the short run, the real exchange rate appreciates. This is because of higher consumption demand. This increases domestic interest rates and appreciates the domestic currency. Though the exchange rate subsequently depreciates (relative to the initial peak), it remains appreciated also in the long run (relative to the initial equilibrium). Note, interest parity requires an initial appreciation because of an expected depreciation during the period in which he domestic interest rate exceeds the foreign rate. The long run appreciation is a Balassa-Samuelson type of effect. The TFP shock in sector 1 increases wages in both sectors, which increases the prices of all goods in the domestic economy. Since the real exchange rate is defined over the consumption basket (which are only partially traded), the real exchange rate expresses the relative price of consumption goods in the domestic economy relative to the foreign economy. More relevant for the trade balance is the terms of trade for sector 1 goods, which is declining.

The trade balance deteriorates initially and improves subsequently with rising demand in the RoW, since it takes time for lower investment goods prices (technology transmission) to raise investment in the RoW. Domestic firms increase FDI in RoW, because the positive transmission of the technology shock leads to a gradual increase of foreign income. In addition, there is a productivity gain associated with the "foreign bias" of investment. This lowers marginal cost for foreign affiliates which increases market share. Exactly the opposite happens with regard to the FDI of foreign firms which experience a competitiveness loss relative to domestic firms (different mix of investment goods). In the short run, this leads to a positive PRB. However, domestic FDI producers (affiliates of foreign multinationals) also gain from rising income in the domestic economy which increases revenue for their goods, which increases distributed profits. The latter effect dominates and the PRB turns negative.

### *Diffusion*

With technology diffusion, a sector 1 TFP shock can be associated with a positive trade balance and an exchange rate depreciation. Differences of the external adjustment with and without diffusion is best understood by the domestic and foreign response of private consumption. With diffusion the technology shock is asymmetric namely an instantaneous domestic permanent level shift of technology compared to an anticipated gradual increase of TFP in the foreign economy. This implies a faster increase of productive capacity in the domestic economy, while permanent income consumers increase consumption in response to the expected permanent rise in income. Because of differences in supply excess demand is higher in the foreign economy initially and drives up RoW interest rates, which leads to a depreciation of the domestic currency. The combination of initially rising demand and depreciation of the domestic currency turns the domestic trade balance positive.

**Figure 3a: Permanent increase of TFP in sector 2 (no diffusion)**

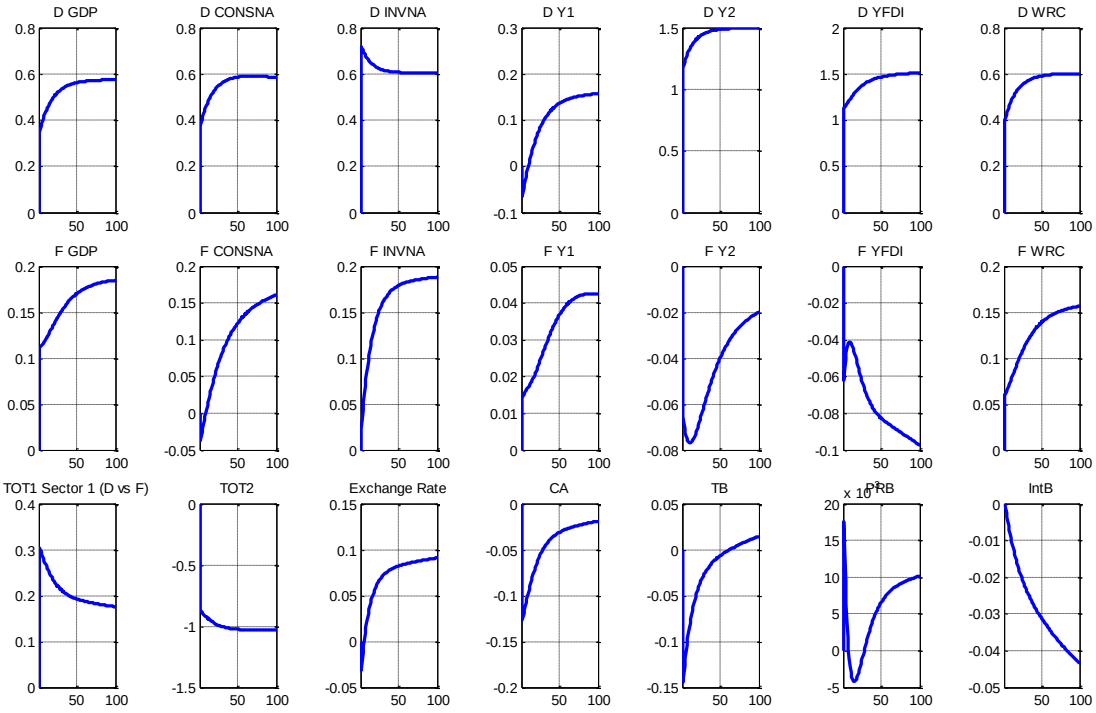
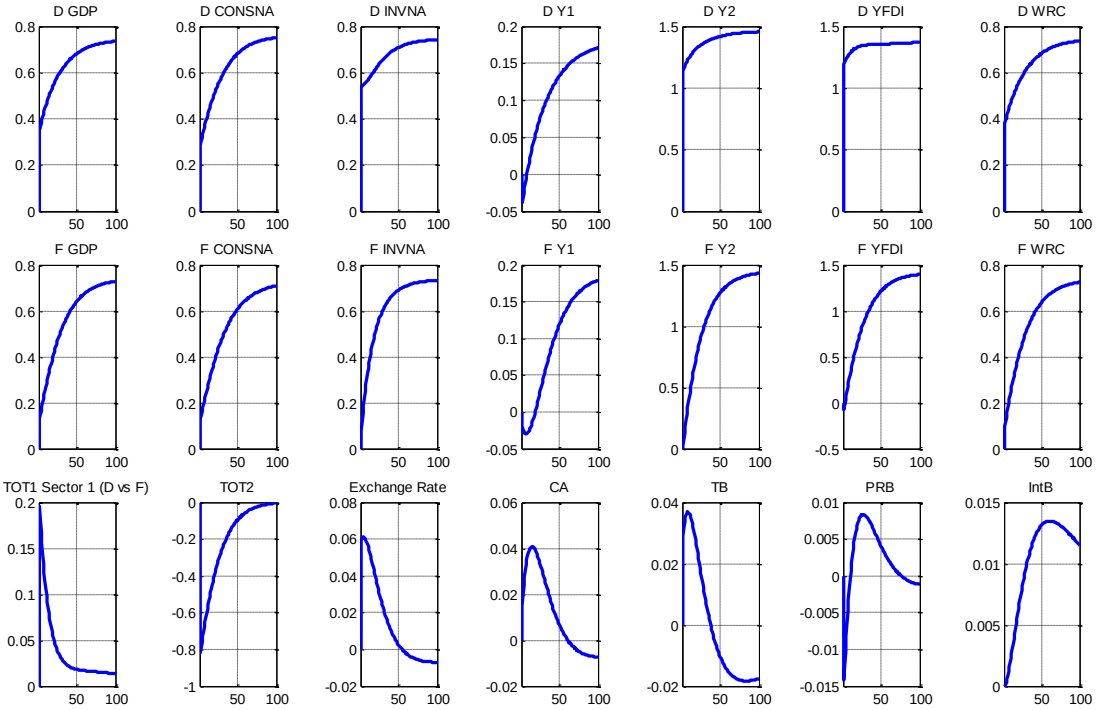



**Figure 3b: Permanent increase of TFP in sector 2 (with diffusion)**




*Source: Own representation*

***No Diffusion***

Sector 2 increases production both domestically and abroad. Thus, the transmission of the technology shock to the RoW is larger if it is associated with multinationals who transfer technology to their foreign affiliates. FDI production increases immediately because of the TFP shock. Since FDI production of domestic MNCs increases more than domestic GDP, TFP shocks in sector 2 exceeding those in sector 1 could explain why the share of FDI production is rising over time.

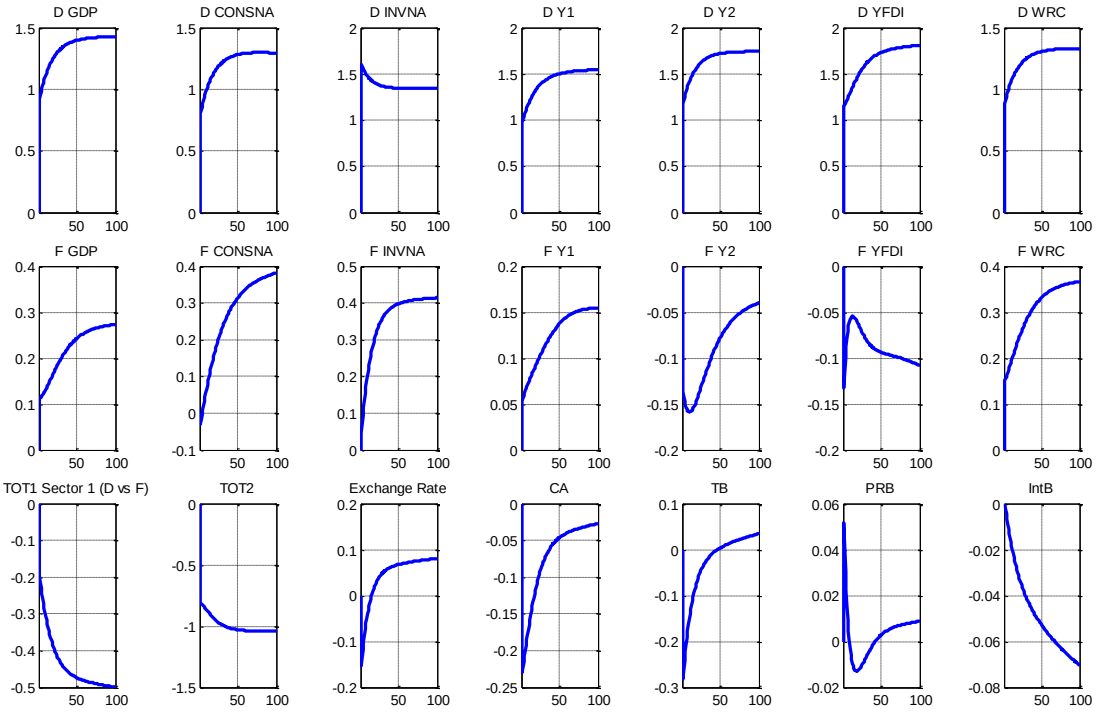
Similar to the TFP shock in sector 1, the real exchange rate first appreciates, because demand initially exceeds capacity, which is slow to build up because of investment adjustment frictions. However, in the medium and long run, the exchange rate depreciates. In this case the Balassa-Samuelson effect works in the other direction. Now, exporting firms become less competitive because the sector 2 TFP shock increases wages in the tradable sector, which increases the ToT. External balance therefore requires a real depreciation in the long run.

After an initial increase, the PRB declines and only recovers gradually. The initial increase can be explained by rising revenues associated with an increase in market share. This is followed by an investment period, with a decline in distributed profits. After the new level of the capital stock is reached, the PRB rises.

***Diffusion***

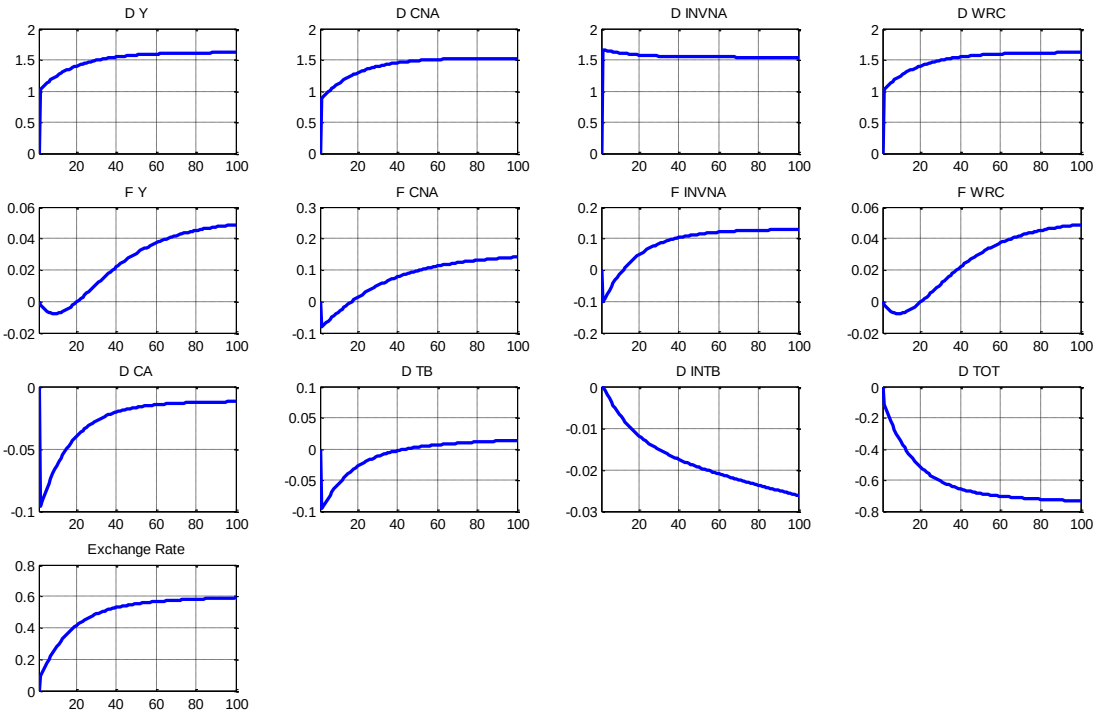
With diffusion the exchange rate moves in the opposite direction for the same reason as discussed above.

## Figure 4: Permanent increase of TFP in sector 1 and 2 (no diffusion)




*Source: Own calculations*

## Figure 5: Permanent increase of TFP in a one-sector economy (no diffusion)




*Source: Own calculations*

The joint technology shock in the three-sector model can best be compared to the standard one-sector model. There are some noteworthy differences. The technology shock in the three-sector model is smaller since it only originates with domestic producers (not with the affiliates of foreign MNCs), but it is transmitted directly to the foreign affiliate of the domestic MNC. This explains why the transmission of the TFP shock is more positive. The other difference concerns the exchange rate. In the three-sector model, the ToT declines but the exchange rate appreciates, while in the one-sector model the real exchange rate depreciates.

## Product innovation

An increase of product varieties will be considered for the case that sector 1 or sector 2 are concerned – without and with international diffusion in the respective sector.

**Figure 6a: Permanent increase of variety in sector 1 (no diffusion)**

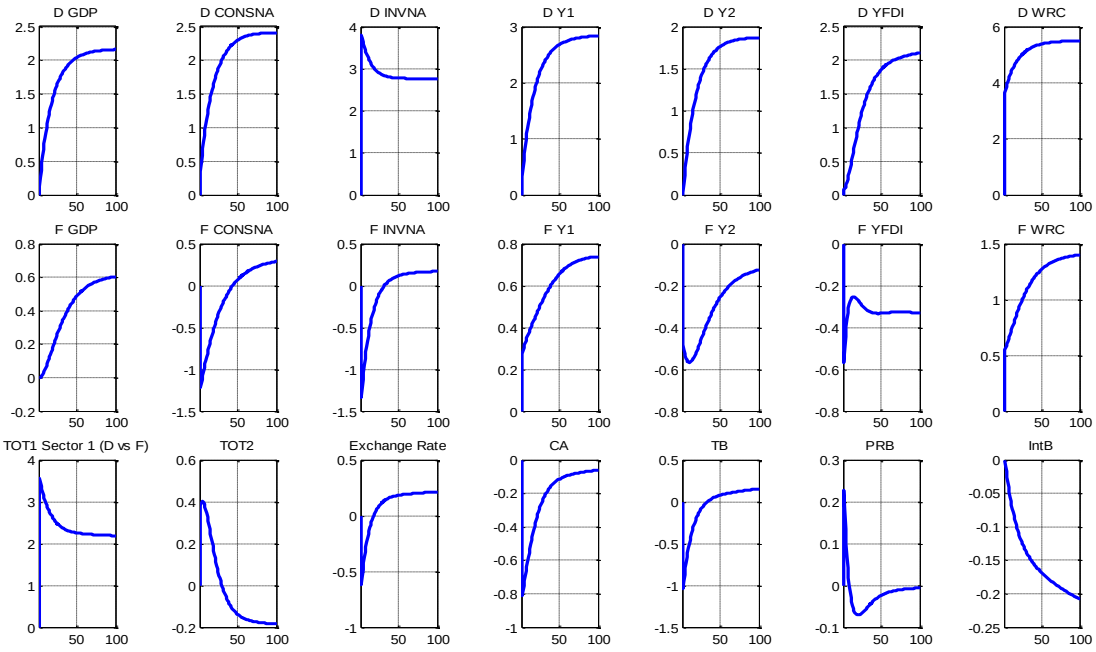
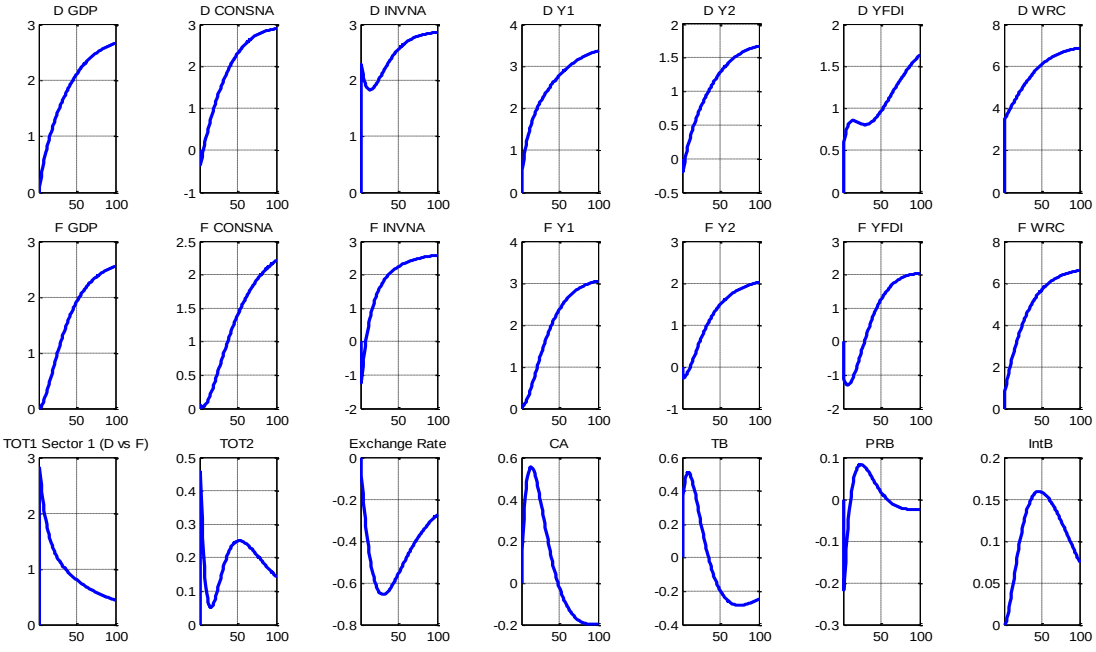



**Figure 6b: Permanent increase of variety in sector 1 (with diffusion)**




*Source: Own calculations*

Demand for domestic sector 1 goods increases at home and abroad. This has positive spillover effects on sector 2 and the domestic FDI producers. The foreign export sector also benefits from rising production in the domestic economy.

Due to the increasing domestic demand, there is an appreciation of the exchange rate. The demand effect is even stronger, because consumption rises immediately, while product innovation is only gradually increasing production levels, as the capital stock becomes more productive. This takes time because of investment adjustment costs.

Therefore, the TB declines strongly initially. Though there is a shift in demand towards exports, the increase in domestic demand However, product innovation implies a shift towards domestic exports. This turns the trade balance positive in the medium term.

Product innovation also gives a boost to the FDI of domestic multinationals because of the foreign bias of investment goods. This increases productivity of FDI in the foreign economy relative to domestic production. The output of domestic FDI production declines slightly, but revenue increases because the price level (Balassa Samuelson effect) increases. Therefore, the effects on the PRB are ambiguous.

***Diffusion***

Due to the anticipated foreign product innovation effects, the trade balance changes sign. Initially there is a jump appreciation of the exchange rate followed by a depreciation. The latter is required because of higher expected foreign demand with an expected increase in the foreign interest rate. The initial appreciation is required by the fact that the exchange rate will eventually turn to the baseline level once diffusion of technology is completed.

**Figure 7a: Permanent increase of variety in sector 2 (no diffusion)**

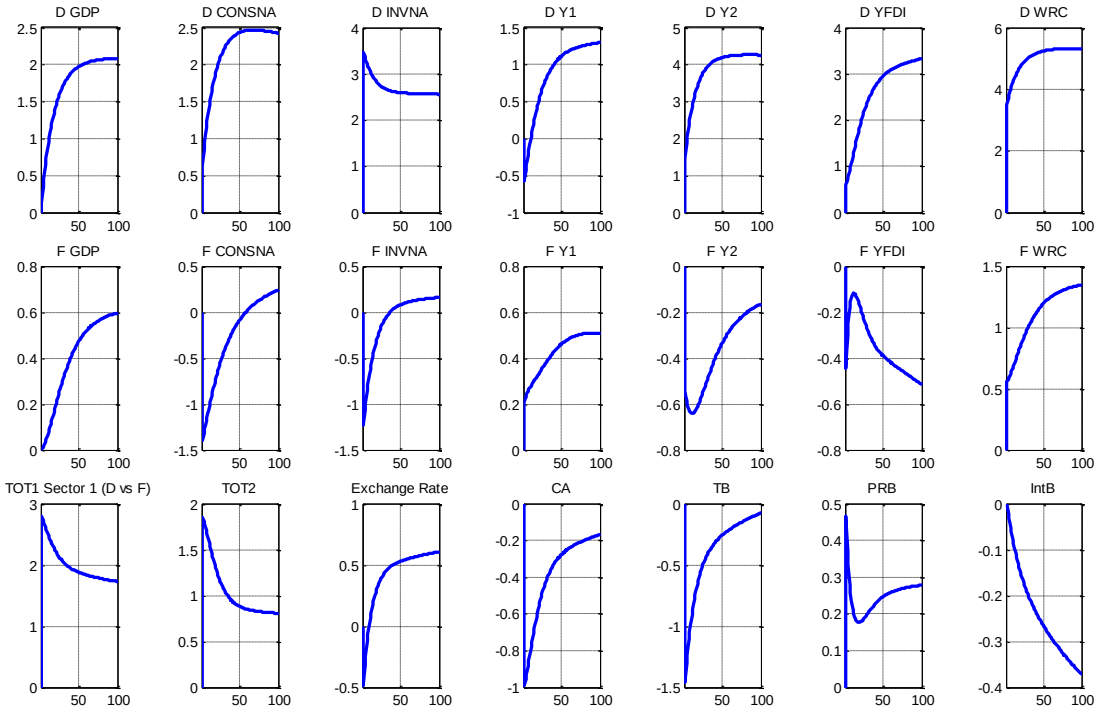
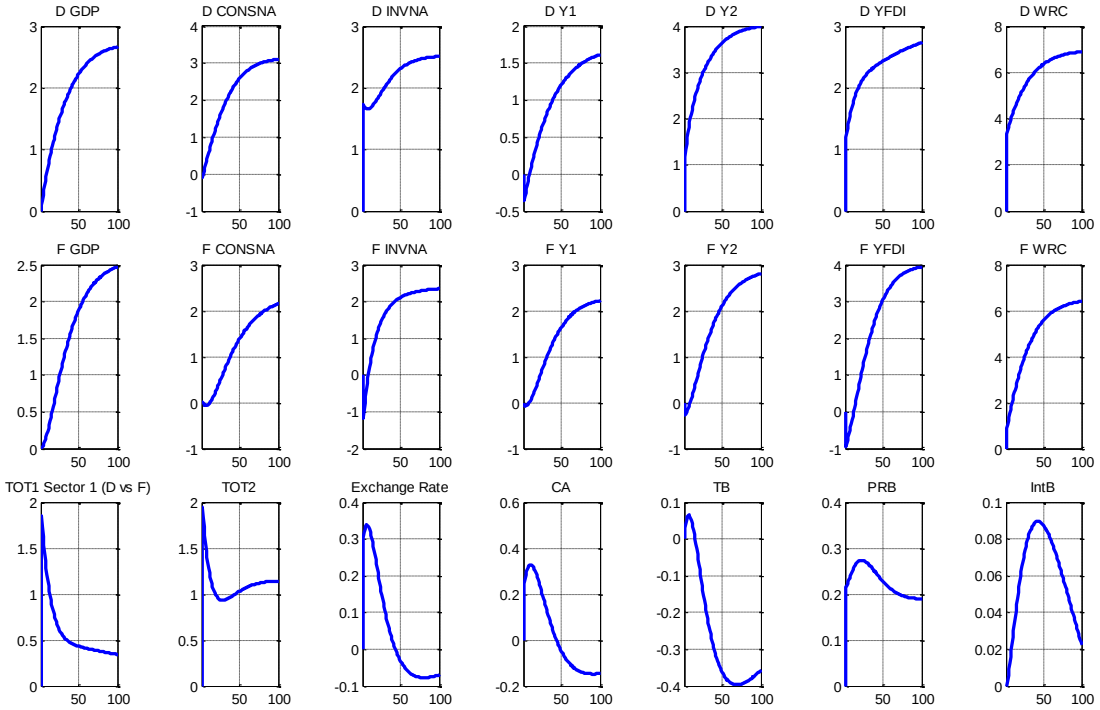



**Figure 7b: Permanent increase of variety in sector 2 (with diffusion)**




*Source: Own calculations*

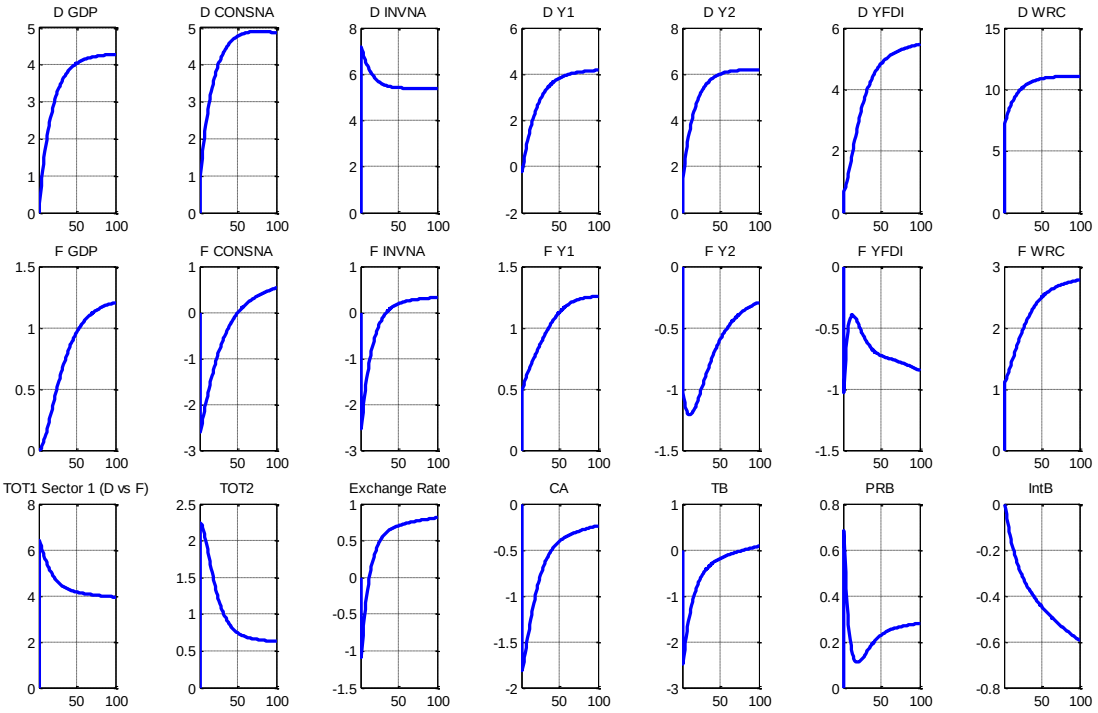
Product innovation in sector 2 increases production in sectors 1 and 2 because of productivity spillovers across sectors (investment aggregate) and sectoral consumption demand spillovers. However, sector composition changes in favor of sector 2 in the domestic economy. FDI also increases because of a rising demand and investment specific technical progress.

Since the terms of trade for sector 1 increase (Balassa Samuelson effect), the trade balance deteriorates. However, the PRB improves persistently, because FDI benefits from both a positive demand shock (increase of demand for domestic sector 2 goods by foreigners) and improved efficiency of FDI investment aggregate.

***Diffusion***

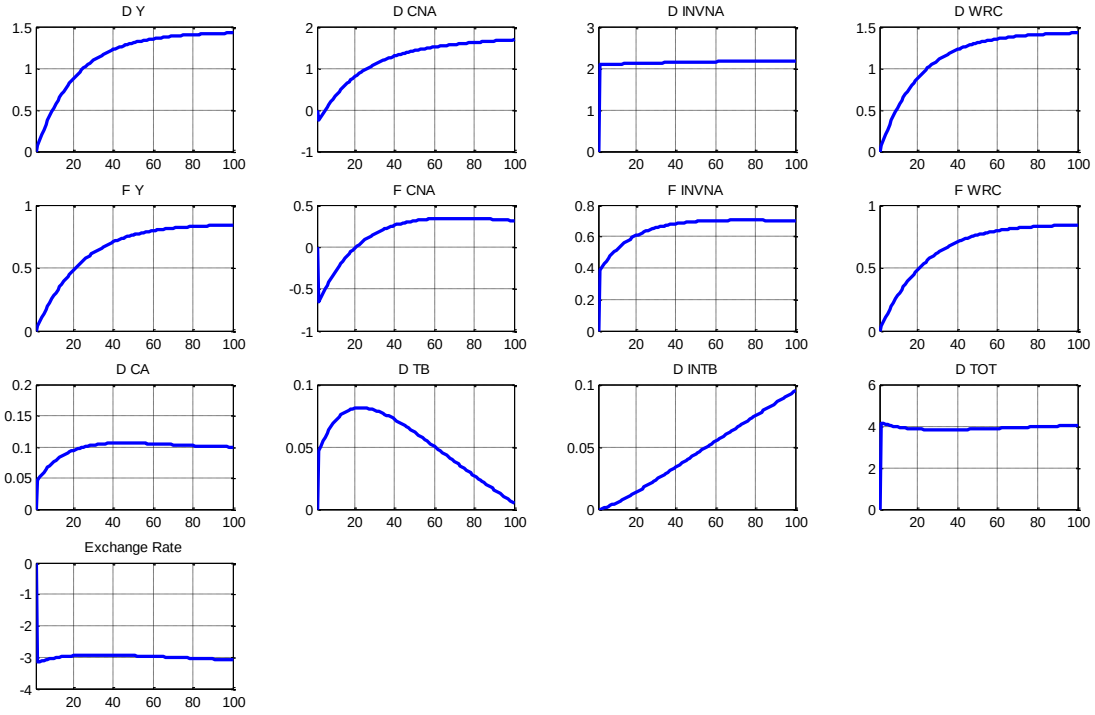
The trade balance and primary income balance preserve sign but become smaller and deviations from the baseline become less prolonged. The exchange rate initially appreciates due to the anticipated consumption effects abroad.

**Figure 8: Permanent increased variety in sector 1 and 2 (no diffusion)**




*Source: Own calculations*

**Figure 9: Permanent increased variety in a one-sector economy (no diffusion)**




*Source: Own calculations*

## Technology spillovers

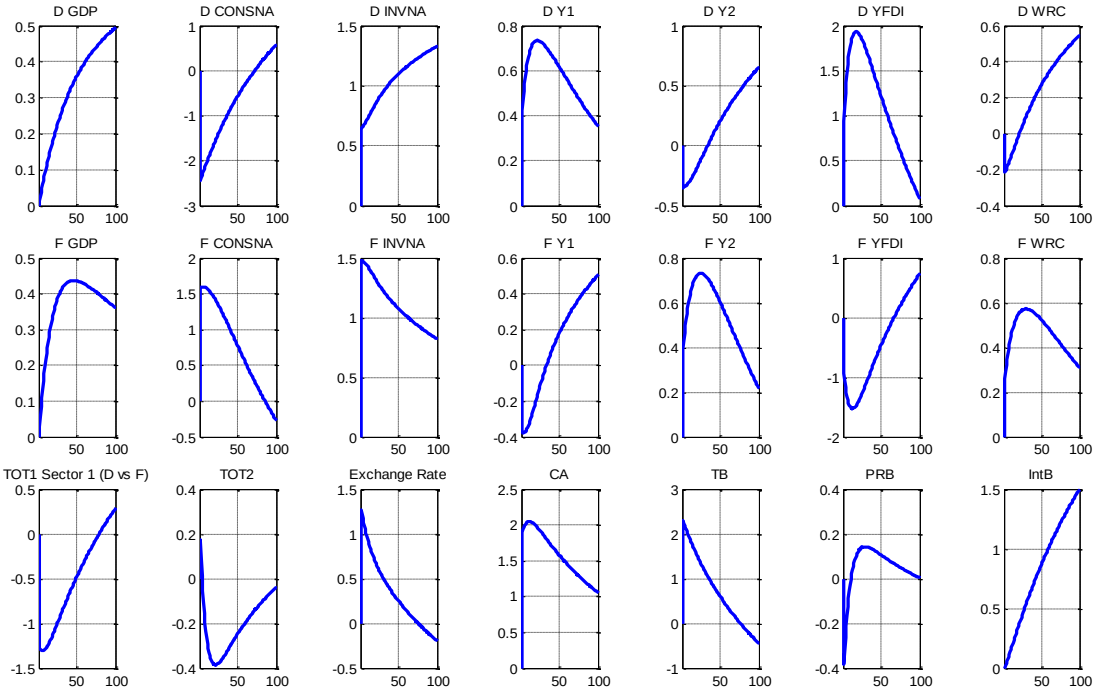
There is a substantial literature on technology spillovers at business cycle frequency of both TFP and investment specific technical progress (see, for example, CRAVINO/LEVCHENKO, 2017 and MANDELMAN ET AL., 2010). In this section we explore long run spillover effects of both product and process innovation shocks and the contribution provided by FDI. Standard models usually concentrate on TFP shocks and find limited spillovers in the case of zero technology diffusion. Adding an FDI sector allows for a significant increase of cross country spillovers. Here we concentrate on long run spillover effects. This can be seen by comparing the TFP shock originating in sector 1 to the TFP shock originating in sector 2. In the former case, foreign GDP only rises by about 10% compared to domestic GDP in the long run, while in the latter case is rises by about 25%, due to a direct technology spillover from the parent MNC to the foreign affiliate and further indirect linkages via investment. We also find that product innovation shocks generate higher spillovers compared to process innovations, since product innovations improve the quality of investment. In this case the GDP spillover effect between sector 1 and sector 2 innovations is similar, with a long run spillover effect of about 27% given our calibration. A sector 1 product innovation shock increases productivity because sector 1 and sector 2 in the foreign economy buys investment goods from sector 1. A sector 2 product innovation shock increases productivity because the foreign affiliate of the domestic MNC uses sector 2 investment goods and produces investment goods which are used by foreign sector 1 and 2. This suggests that if one abstracts from direct technology diffusion effects the

inclusion of FDI increases the international spillovers from TFP shocks and it opens up an FDI channel for the transmission od sector 2 innovations to the RoW.

### Savings Shocks

A savings shock in the two-sector approach is considered in the subsequent graphs (see Figure 10) – with the discount rate of households increasing; for comparison Figure 11 shows the one sector case (no FDI).

**Figure 10: Permanent positive savings shock (∆β^c>0)**




*Source: Own calculations*

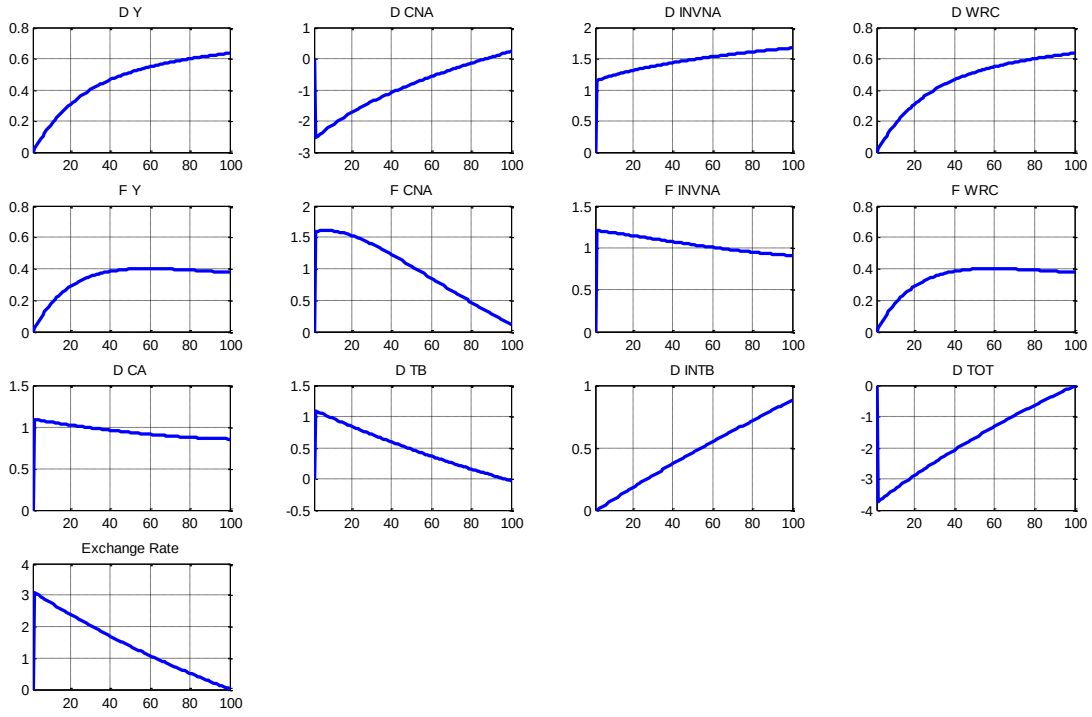
This shock can generate persistent TB and CA surpluses. The exchange rate initially depreciates because of a decline in the domestic interest rate associated with the negative demand shock. In the longer run, the exchange rate appreciates since higher savings lead to higher investment (at home and abroad), which increases income and consumption.

There is co-movement between the TB and PRB in the medium run but not in the short run. In the short run, distributed profits are smaller because of higher investment abroad. A savings shock leads to more foreign production of domestic multinationals and foreign multinationals reduce production in the domestic economy. In the long run there is a complete reversal. The FDI production of foreign multinationals in the domestic economy increases (driven by rising income in the domestic economy), while the FDI of domestic multinationals declines

(appreciation of domestic currency, increases capital cost of foreign affiliates because of a foreign bias for investment goods).

As can be seen from the following figure, the two models behave similarly w. r. t. the saving shock.

**Figure 11: Permanent positive savings shock in one-sector economy (Δβ^c>0)**




*Source: Own calculations*

***Lessons for observed persistent CA imbalances***

Our analysis has shown that technological innovations and persistent saving shocks originating in one country can have long-lasting effects on the current account and its components[1]. Depending on the sectoral origin (export vs. FDI), the type of innovation (process vs. product) and the speed of diffusion (no diffusion vs. gradual diffusion), different patterns of external balance dynamics can emerge. It appears that for all technology shocks there is an initial decline of the current account and it remains negative for a long period of time. This is consistent with foreign capital flowing into the domestic economy because of increased return on capital. Only the savings shock can generate a persistent increase in the current account. This, in turn, is generated by an outflow of savings. Investing all additional savings domestically would be inconsistent with international return equalisation. The current account is largely driven by the trade balance but there can be differences between the adjustment of the trade balance and the primary income balance. A TFP shock and a product innovation shock in sector 1 tend to be associated with negative primary income balance in the medium term, while a sector 2 TFP and product innovation shock lead to a positive evolution of the primary income balance.

Given these shock specific differences of the trade and primary income balance adjustment allows to shed some light on the origins of persistent external imbalances which can be observed for some countries. As shown by Figure 1A, Germany and the US are countries with the most pronounced external imbalances. There are other countries like Spain, Italy. France and Japan which show deviations in recent years. Canada, the Republic of Korea and Sweden show imbalances in the past but a tendency of declining imbalances in recent years. The Netherlands appears to be another country with a rising trade balance. As shown by SUYKER/WAGTEVELD (2019), this pattern is likely to be explained by savings behaviour of MNCs related to specific tax arrangements. Explaining these pattern goes beyond the scope of this paper. We concentrate on Germany and the US.

***Germany:***

Based on our model and calibration, the persistent positive trade balance since the early 2000s, followed by a positive primary income balance is most consistent with a positive shock to savings. The savings shock can explain a positive CA mostly driven by a positive trade balance and followed by a positive primary income balance. Process innovations both in the German export sector (small and medium sized enterprises) and for German multinationals can generate a positive trade balance and a delayed positive PRB (in case of a sector 2 process innovation) but not a positive CA. Thus, we cannot exclude process innovations as a possible driver of the German TB, but it must come along with a positive shock to savings. Process innovation with diffusion is also a possible candidate, since it can generate a positive CA, TB and PRP. However, with diffusion, imbalances are less persistent.

***United States:***

The only shock which generates a CA deficit, a trade deficit and a positive PRB, is the product innovation shock in sector 2. This points in the direction of US multinationals and their product

[1] Here, we concentrate on the no diffusion case since we want to study the effects of permanent international shocks.

innovation activities play a crucial role for generating this pattern. The pattern has existed for a long time, but there has been a further divergence between the TB and the PRB beginning at the end of the 1990s, a time when the IT boom took off in the US, with the creation of superstar firms in the information and communication sector (new ICT services (Microsoft, Google, Apple, Facebook etc.), sharing platforms (e.g., Uber, Airbnb), and e-commerce innovations in retail (e.g., Amazon)). The international activities of these firms are largely FDI based.

# 5. Conclusions and Economic Policy Perspectives

The new approach developed herein adds FDI investment to an otherwise standard DSGE model with a tradable and non-tradable sector and explores the international transmission of technology and savings shocks; and we consider a wide range of technology shocks differentiated by product and process innovations and by sectoral origin. FDI investment and income flows also allow us to see how individual components of the current account respond to demand and supply shocks and we identify characteristic patterns related to specific shocks. We are especially interested in seeing whether the impulse responses to permanent shocks can tell us something about the reasons for persistent external imbalances in countries like Germany and the United States. For the US we find that product innovations originating from US multinationals, at least qualitatively matches well the negative current account and trade balance and a positive primary income balance. The German/Eurozone CA surplus is less easy to explain by technological factors since in our model all technology shocks are associated with persistent CA deficits. Our model confirms what has been shown in previous studies that the German CA is strongly driven by savings. We add to this the observation that increased savings also shows up in an improved primary income balance, which can indeed be observed for Germany. As regards the model presented, process innovations in the FDI-based sector seem to be of particular importance – a well-established finding for large OECD countries. Technology shocks which raise the relative output share in the FDI-based sector indirectly contribute to both higher global output and higher per capita income.

The focus of this paper is on the effects of permanent shocks. In future research, we also intend to add nominal rigidities in goods and labor markets to the model in order to analyze how the presence of FDI and multinationals affects the impact of demand and supply shocks on inflation. Initial empirical evidence suggests that inward FDI intensity and outward FDI intensity affect the medium-term inflation-unemployment rate trade-off (WELFENS/CELEBI, 2021).

Many additional applications of this model can be considered which could include: (i) FDI and international income convergence; (ii) trade tariffs and FDI; a country imposing tariffs can benefit from more FDI – e.g. in line with tariff-jumping standard arguments; (iii) taxation issues concerning multinational companies as multinational companies can engage in transfer pricing; (iv) the model can be calibrated to industrial countries vs. emerging economies which could be quite relevant as an analytical and economic policy perspective in a G20 perspective; (v) innovations can be endogenized so that standard elements of, for example, Schumpeterian destruction could be considered in a broader international modelling context. (vi) The model

also offers possibilities to study industrial and trade policy strategies either oriented towards opening up trade and/or attracting FDI inflows.

### *Schumpeterian FDI-related Policy Perspectives*

The analysis presented has clearly demonstrated the importance of FDI and product as well as process innovation dynamics and savings shocks for macroeconomic development. Current account balance changes cannot be understood adequately without taking a closer look at the primary balance which, in many countries, is strongly influenced by the stock of inward and outward FDI, respectively. Technology shocks indeed matter where process and product innovations have rather different effects on exchange rate adjustments. The fact that innovation dynamics raise relative output growth of the FDI-based sector suggests that OECD countries with slow growth would be well advised to put more of an emphasis on an adequate R&D promotion policy: with a focus on both product and process innovations on the one hand, while better incentives for the creation of new multinational companies could also be useful on the other hand (think, for example, of a country such as Italy which could benefit from a two-pronged supply-side policy, namely with a twin focus on innovation and more multinationalization; thus far, this has not been a focus of EU policy monitoring such as within the context of the European Semester of EU member countries). At the bottom line, this new approach should be useful for further research and various policy perspectives.

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# Appendix A: Selected FDI Statistics for the US and other OECD Countries

The share of sales in host countries has dropped to 58 percent in 2018, with only 54.3 percent in Manufacturing, and almost 61 percent in Non-manufacturing. Sales back to the US have increased since 1999 to 11.92 percent, while sales to unaffiliated parties in other foreign countries has risen to 14.51 percent, with sales to related affiliates also rising to 15.52 percent (an increase from 12.5 percent in 1999). The share of local sales in the host countries in Europe has fallen considerably – namely from 65.9 percent in 1999 to 50.33 percent in 2019 (as has the share of local sales in the Asia and Pacific and Latin American regions), while the share of sales back to the US from MNCs in Europe has more than doubled (4.4 percent to 9.03 percent) reflecting perhaps the effect of EU eastern enlargement on the one hand, on the other hand the expansion of FDI in the ICT could play a role: particularly with regard to low tax jurisdictions such as Ireland or the Netherlands – acting as conduits between the US and the rest of the world.

**Table A1: Sales of US Multinational Companies Worldwide in 1999 and 2018 (data for affiliates), Millions of US Dollars**

| | Local Sales in Host Country | | Sales back to the US | | Sales to Un-affiliated Parties in Other Foreign Countries | | Sales to Related Affiliates in Other Foreign Countries | |
|---|---|---|---|---|---|---|---|---|
| **1999** | **Dollars $** | **% of Total** | **Dollars $** | **% of Total** | **Dollars $** | **% of Total** | **Dollars $** | **% of Total** |
| All US | 1,494,903 | 67.4 | 230,975 | 10.4 | 216,163 | 9.74 | 276,904 | 12.5 |
| Manuf. | 651,982 | 58.9 | 165,731 | 15 | 110,119 | 9.9 | 179,533 | 16.2 |
| Non-Manuf. | 842,921 | 75.8 | 65,244 | 5.9 | 106,044 | 9.5 | 97,371 | 8.8 |
| Canada | 197,222 | 70.1 | 78,081 | 27.8 | 3,600 | 1.3 | 2,348 | 0.8 |
| Europe | 803,860 | 65.9 | 53,629 | 4.4 | 159,130 | 13 | 203,850 | 16.7 |
| Asia and Pacific | 304,177 | 71.4 | 47,255 | 11.1 | 30,944 | 7.3 | 43,904 | 10.3 |
| Latin America | 165,678 | 65.9 | 43,544 | 17.3 | 18,620 | 7.4 | 23,722 | 9.4 |
| **2018** | | | | | | | | |
| All US | 3,764,968 | 58 | 772,979 | 11.92 | 941,380 | 14.51 | 1,007,160 | 15.52 |
| Manuf. | 1,530,926 | 54.3 | 380,013 | 13.47 | 380,672 | 13.5 | 529,216 | 18.76 |
| Non-Manuf. | 2,234,042 | 60.95 | 392,966 | 10.72 | 560,708 | 15.30 | 477,944 | 13.04 |
| Canada | 472,655 | 75 | 131,418 | 20.86 | 14,246 | 2.26 | 11,812 | 1.87 |
| Europe | 1,595,532 | 50.33 | 286,358 | 9.03 | 631,732 | 19.93 | 656,382 | 20.7 |
| Asia and Pacific | 1,145,136 | 63.4 | 204,428 | 11.31 | 217,977 | 12.06 | 239,836 | 13.27 |
| Latin America | 451,886 | 62.7 | 129,346 | 17.95 | 61,561 | 8.54 | 77,671 | 10.78 |

*Note: Manuf. Refers to manufacturing and Non-manuf. to non-manufacturing*

*Source: Own calculations based on data from the BEA U.S. Direct Investment Abroad (USDIA) data, 1999 (Table III.F.1) and BEA Worldwide Activities of U.S. Multinational Enterprises: Preliminary 2018 Statistics, Table II.E.1*

Total assets represented by affiliates experienced an 18-fold increase in the period 1990-2019. Value-added in foreign affiliates reached 9.1 percent in 2019 in the world economy; however, as FDI inflows and outflows are largely concentrated in about fifty countries - which represent about two-thirds of the world economy - the relevant ratio of FDI-based value-added to GDP in the fully globalized part of the world economy, i.e. countries with both trade and FDI inflows and FDI outflows, was rather close to 12 percent (for the US plus the EU28 the relevant ratio could be even around 15 percent). As UNCTAD data reports sales of affiliates which are roughly four times as high as value-added, intermediate products quite apparently play a large role in the FDI-based production of goods and services. Employment in affiliates reached almost 83 million in 2019. The compounded annual growth rate for royalties and license fee receipts was 12.4 percent in the period 2000-07, but much smaller in 2008-19 (at 5.4 percent). At the bottom line, FDI has become more important over time in the world economy and also

more technology-driven. Besides OECD countries – traditionally standing for high FDI flows – China has become a crucial FDI country, both as a host country and increasingly also as a source country of FDI. Value-added in foreign affiliates as a percentage of GDP in the FDI countries covered in the subsequent table has increased from a share of 5.6 percent in 1990 to 9.2 percent in 2019 where aspects of international profits shifting and multinational transfer pricing, respectively, might have distorted the UNCTAD figures.

**Table A2: FDI and the Evolution of International Production since 1990 (in billions of US$ and percent)**

| | | | | | | CAGR (%) | | |
|---|---|---|---|---|---|---|---|---|
| | **1990** | **2000** | **2007** ***(pre-crisis peak)*** | **2010** | **2019** | **1990s** | **2000-2007** ***(pre-crisis)*** | **2008-2019** ***(post-crisis)*** |
| FDI inflows* | 205 | 1356 | 1891 | 1365 | 1540 | 20.8 | 4.9 | 0.4 |
| FDI inward stock* | 2196 | 7377 | 18634 | 19751 | 36470 | 11.6 | 13.5 | 8.4 |
| Income on inward FDI* | 82 | 347 | 1260 | 1393 | 1953 | 15.5 | 20.2 | 4.5 |
| Rate of return on inward FDI (%) | 3.7 | 4.7 | 7 | 7.1 | 6.7 | .. | .. | .. |
| Cross-border M&As value* | 98 | 959 | 1032 | 347 | 483 | 25.6 | 1.0 | -2.2 |
| M&As to FDI ratio (%) | 47.9 | 70.7 | 54.5 | 25.3 | 31.3 | .. | .. | .. |
| Geographical spread of inward FDI stock (number of countries that together account for 90% of inward FDI stock) | 23 | 31 | 37 | 40 | 40 | .. | .. | .. |
| Sales of foreign affiliates* | 7136 | 11859 | 26394 | 23392 | 31288 | 5.2 | 12.4 | 1.8 |
| Value added (product) of foreign affiliates* | 1335 | 3059 | 6132 | 6509 | 8000 | 8.7 | 10.4 | 2.0 |
| Total assets of foreign affiliates* | 6202 | 22761 | 74504 | 82588 | 112111 | 13.9 | 18.4 | 4.5 |
| Employment by foreign affiliates (thousands) | 28558 | 50088 | 65041 | 57590 | 82360 | 5.8 | 3.8 | 3.2 |
| *Memorandum* | | | | | | | | |
| GDP* | 23719 | 33845 | 47571 | 66062 | 87127 | 3.6 | 5.9 | 2.9 |
| Gross fixed capital formation* | 5811 | 7920 | 11092 | 15329 | 21992 | 3.1 | 8.4 | 3.3 |
| Royalties and license fee receipts* | 31 | 89 | 152 | 230 | 391 | 11.1 | 12.4 | 5.4 |
| Royalties and license fee receipts *relative to* value added (product) of foreign affiliates (%) | 2,3 | 2,9 | 2,5 | 3,5 | 4,9 | 127.6 | 119.2 | 270 |

** ($ billions) Source: UNCTAD (2020), World Investment Report, Tab. IV.1, p. 124, and own calculations*

The US is the largest source country of foreign direct investment (outward FDI stock) and it also is a leading host country in the world economy (inward FDI stock). Between 1980 and 2017, the ratio of the outward capital stock to the source country's total capital stock has increased in most OECD countries and the US was a leading foreign investor with a ratio of 10.4 percent of its national capital stock (which includes real estate) so that it becomes clear that the "outward US economy" was indeed rather large in 2019; compared to 1980 when the outward ratio was 4.1 percent the increase of US FDI was strong, namely 6.3 percent of the US capital stock (see Table A3). Since land outside the US is typically cheaper than in the United States, one could also point out that adjusting for the "terms of capital" – as an analogy to purchasing power parity figures for income – would raise the effective relative size of the outward US economy; and similarly, for other OECD countries. As regards countries such as Luxembourg, Ireland, the Netherlands and Belgium, there are often strong elements of holding company investments (due largely to tax avoidance motivations) associated with inward FDI outflows: from the foreign holding company in these countries, outward FDI flows then flow back to final FDI destination countries so that the positions of the four aforementioned countries in FDI inward stock relative to the capital stock reflect a certain bias. Disregarding these four countries, the UK, Sweden, Denmark, Finland, Austria, France, Spain and the US were the leading countries for the outward ratio in 2019 with 20.3, 16.8, 16.3, 12.4, 11.8, 11.7, 11.1 and 10.4 percent respectively (Tab. A3); on the inward side the top ratios (inward FDI stock/capital stock of host country) the indicator value for Estonia, the UK, Poland, Slovakia, Hungary, Czech Republic, Portugal, Sweden, Spain and the US achieved 24.1, 21.2, 17.7, 17.4, 15.6, 14.7, 14.6, 14.0, 13.5 and 12.7 percent, respectively (Tab. A4). US FDI flows also were influenced by one-off effects in recent years, namely in the context of a tax reform under the Trump Administration which reinforced the repatriation of profits accumulated abroad which had been held offshore.

If one excludes - in the context of holding company distortion issues - only Luxembourg and Ireland, the Netherlands and Belgium would be the top countries even if one assumes that only two-thirds of the figures indicated for 2017 represents true FDI related to the Netherlands and Belgium. As regards the US outward FDI ratio and the inward FDI ratio, one may argue that US FDI inflows and outflows have strongly increased over decades, but inward FDI dynamics (+9.7 percentage points in the period 1990-2019, compared to a percentage point change of +6.3 percentage points in the period 1990-2019) were apparently much stronger than outward FDI dynamics. Since US investors obtain a higher rate of return on equity abroad than in the US (HUNG/MASCARO, 2004), the figures for 2019 indirectly indicate that the US could have obtained net profits from abroad of about 1 percent of US GDP if one assumes an international risk premium of 2 percent – a pragmatic estimate here. Country i's net profit ratio (NPR) from the outward FDI relative to country i's capital stock minus the inward FDI profit ratio can be written (with outward FDI stock intensity denoted here as $F'_i$, inward FDI stock intensity denoted as $F^{*'}_i$, $R_i$ denoting the domestic rate of return on capital K and d" a positive yield lead indicator for the profit rate abroad) as follows:

(1) $NPR = F'_i R_i (1+d''_i) - F^{*'}_i R_i > 0$

In a more complex setting one may consider $d''_i$ and also a foreign investors' risk premium d"* for F*' (here d"* is assumed for simplicity to be zero). The net profit ratio exceeds zero if:

(2) $F'_iR_i(1+d''_i) > F^{*'}{}_iR_i$

For the US case, we get for 2019:

(2.1) $10.4(R^{us}(1+d''^{us})) - 12.7R^{us}>0$

(2.2) $-2.3\ R^{us} + 10.4R^{us}d''^{us}>0$

The relative foreign yield differential indicator $d''^{us}$ thus should exceed 22,12 percentage points if the net profit ratio is to be positive; e.g. if the US yield on investment is 5% the yield of US subsidiaries should therefore by 6.1% to achieve the critical requirement. For the US an international risk premium of 2 percentage points is a conservative estimate so that the net US profit ratio should certainly have been positive in 2019.

There is a considerable debate in International Economics about vertical FDI versus horizontal FDI which, however, is partly dismissed here. If one considers final product sectors $A_{ik}$ where the index i is for country and k (A, B…Z) for the respective sector – and B to Z are intermediate products for the production of the final goods sector A and there is horizontal outward FDI, this should lead to multinational companies that ever increase in economic size, that is, in terms of value-added and sales relative to world GDP. However, the research by GUTIERREZ/PHILIPPON (2020) shows that the size of leading multinational companies relative to world GDP is not rising over time, rather it is falling or stagnant. This implies that leading multinational companies - in a setting with rising horizontal FDI - obviously increasingly rely on international outsourcing and some offshoring; both developments could raise profitability of multinational companies' foreign direct investment.

## Table A3: Outward FDI Stock Intensity for selected EU Countries, ø EU Core, and USA, 1990-2019, sorted by descending order for 2019

| Country | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LUX | 0,000 | 0,000 | 0,000 | 0,355 | 1,070 | 0,935 | 0,691 | 0,763 | 0,962 | 1,219 | 1,316 | 1,509 | 1,184 | 1,137 |
| IRL | 0,064 | 0,070 | 0,066 | 0,096 | 0,474 | 0,463 | 0,623 | 0,778 | 0,852 | 1,310 | 1,135 | 1,123 | 0,999 | 1,044 |
| NLD | 0,054 | 0,066 | 0,124 | 0,151 | 0,262 | 0,266 | 0,301 | 0,350 | 0,616 | 0,586 | 0,670 | 0,703 | 0,585 | 0,620 |
| BEL | 0,031 | 0,050 | 0,124 | 0,205 | 0,208 | 0,193 | 0,255 | 0,282 | 0,263 | 0,327 | 0,332 | 0,359 | 0,267 | 0,309 |
| **GBR** | **0,033** | **0,057** | **0,122** | **0,099** | **0,185** | **0,169** | **0,176** | **0,198** | **0,168** | **0,176** | **0,178** | **0,208** | **0,185** | **0,203** |
| SWE | 0,026 | 0,048 | 0,074 | 0,074 | 0,150 | 0,134 | 0,147 | 0,161 | 0,147 | 0,154 | 0,152 | 0,157 | 0,155 | 0,168 |
| DNK | 0,009 | 0,026 | 0,078 | 0,055 | 0,118 | 0,127 | 0,137 | 0,136 | 0,119 | 0,136 | 0,141 | 0,164 | 0,152 | 0,163 |
| FIN | 0,015 | 0,030 | 0,103 | 0,092 | 0,154 | 0,138 | 0,166 | 0,145 | 0,110 | 0,101 | 0,114 | 0,118 | 0,109 | 0,124 |
| AUT | 0,005 | 0,009 | 0,019 | 0,032 | 0,082 | 0,083 | 0,105 | 0,111 | 0,104 | 0,118 | 0,114 | 0,126 | 0,113 | 0,118 |
| **FRA** | **0,015** | **0,037** | **0,039** | **0,044** | **0,085** | **0,085** | **0,091** | **0,094** | **0,092** | **0,106** | **0,108** | **0,118** | **0,113** | **0,117** |
| ESP | 0,005 | 0,011 | 0,035 | 0,040 | 0,102 | 0,099 | 0,098 | 0,098 | 0,091 | 0,104 | 0,112 | 0,120 | 0,106 | 0,111 |
| EU Core (ø) | 0,023 | 0,038 | 0,041 | 0,046 | 0,083 | 0,083 | 0,094 | 0,092 | 0,088 | 0,101 | 0,100 | 0,111 | 0,105 | 0,110 |
| **USA** | **0,041** | **0,061** | **0,090** | **0,086** | **0,095** | **0,087** | **0,097** | **0,111** | **0,106** | **0,098** | **0,100** | **0,117** | **0,090** | **0,104** |
| **DEU** | **0,031** | **0,039** | **0,043** | **0,048** | **0,082** | **0,081** | **0,096** | **0,090** | **0,083** | **0,095** | **0,093** | **0,105** | **0,098** | **0,102** |
| EST | 0,000 | 0,001 | 0,005 | 0,022 | 0,064 | 0,053 | 0,066 | 0,069 | 0,060 | 0,066 | 0,068 | 0,078 | 0,070 | 0,087 |
| ITA | 0,008 | 0,018 | 0,026 | 0,020 | 0,039 | 0,042 | 0,051 | 0,050 | 0,045 | 0,052 | 0,056 | 0,062 | 0,059 | 0,062 |
| PRT | 0,001 | 0,005 | 0,023 | 0,035 | 0,053 | 0,050 | 0,054 | 0,068 | 0,056 | 0,066 | 0,068 | 0,067 | 0,051 | 0,054 |
| HUN | 0,001 | 0,001 | 0,004 | 0,014 | 0,042 | 0,048 | 0,078 | 0,079 | 0,079 | 0,081 | 0,058 | 0,059 | 0,051 | 0,053 |
| CZE | 0,000 | 0,001 | 0,001 | 0,003 | 0,011 | 0,010 | 0,015 | 0,018 | 0,017 | 0,019 | 0,020 | 0,031 | 0,035 | 0,039 |
| SVN | 0,000 | 0,004 | 0,006 | 0,015 | 0,029 | 0,027 | 0,032 | 0,031 | 0,027 | 0,030 | 0,032 | 0,036 | 0,032 | 0,035 |
| LTU | 0,000 | 0,000 | 0,000 | 0,004 | 0,018 | 0,020 | 0,026 | 0,026 | 0,022 | 0,026 | 0,026 | 0,028 | 0,028 | 0,027 |
| GRC | 0,003 | 0,003 | 0,007 | 0,008 | 0,024 | 0,025 | 0,031 | 0,028 | 0,024 | 0,024 | 0,018 | 0,020 | 0,019 | 0,020 |
| POL | 0,000 | 0,002 | 0,001 | 0,002 | 0,014 | 0,014 | 0,021 | 0,024 | 0,021 | 0,025 | 0,026 | 0,025 | 0,019 | 0,019 |
| SVK | 0,000 | 0,001 | 0,004 | 0,002 | 0,009 | 0,010 | 0,013 | 0,013 | 0,008 | 0,008 | 0,009 | 0,014 | 0,013 | 0,014 |
| LVA | 0,000 | 0,002 | 0,000 | 0,001 | 0,004 | 0,004 | 0,005 | 0,007 | 0,009 | 0,010 | 0,011 | 0,012 | 0,011 | 0,010 |

**Note:** Outward FDI Stock Intensity = Outward FDI Stock / Source Country Capital Stock. EU Core (ø) represents the unweighted average of France and Germany. 5-year intervals from 1990-2010, annual data thereafter. Capital stock at constant 2017 prices was converted into nominal values with the 2017 capital stock price level data from the same source. **Source:** Own calculations and representation of FDI stock data from UNCTAD and capital stock data from the Penn World Table, version 10.0, Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2015), "The Next Generation of the Penn World Table" American Economic Review, 105(10), 3150-3182, available for download at www.ggdc.net/pwt .

## Table A4: Inward FDI Stock Intensity for selected EU Countries, ø EU Core, and USA, 1990-2019, sorted by descending order for 2019

| Country | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IRL | 0,162 | 0,184 | 0,301 | 0,151 | 0,398 | 0,407 | 0,580 | 0,604 | 0,592 | 1,282 | 1,114 | 1,204 | 1,082 | 1,108 |
| LUX | 0,000 | 0,000 | 0,000 | 0,378 | 0,985 | 1,258 | 0,948 | 0,845 | 1,211 | 1,267 | 1,259 | 1,069 | 0,807 | 0,672 |
| NLD | 0,035 | 0,044 | 0,099 | 0,113 | 0,159 | 0,163 | 0,197 | 0,238 | 0,435 | 0,447 | 0,462 | 0,500 | 0,441 | 0,443 |
| BEL | 0,045 | 0,070 | 0,135 | 0,162 | 0,228 | 0,214 | 0,283 | 0,298 | 0,254 | 0,297 | 0,288 | 0,297 | 0,254 | 0,263 |
| EST | 0,000 | 0,013 | 0,052 | 0,128 | 0,179 | 0,181 | 0,207 | 0,222 | 0,203 | 0,205 | 0,212 | 0,240 | 0,222 | 0,241 |
| **GBR** | **0,030** | **0,037** | **0,057** | **0,063** | **0,117** | **0,113** | **0,150** | **0,167** | **0,158** | **0,168** | **0,166** | **0,212** | **0,200** | **0,212** |
| POL | 0,001 | 0,022 | 0,069 | 0,101 | 0,155 | 0,126 | 0,162 | 0,183 | 0,163 | 0,167 | 0,174 | 0,202 | 0,175 | 0,177 |
| SVK | 0,000 | 0,011 | 0,045 | 0,097 | 0,132 | 0,129 | 0,154 | 0,158 | 0,146 | 0,152 | 0,157 | 0,184 | 0,168 | 0,174 |
| HUN | 0,003 | 0,039 | 0,071 | 0,092 | 0,163 | 0,149 | 0,209 | 0,217 | 0,195 | 0,196 | 0,192 | 0,186 | 0,164 | 0,156 |
| CZE | 0,000 | 0,015 | 0,037 | 0,055 | 0,097 | 0,091 | 0,116 | 0,115 | 0,110 | 0,121 | 0,129 | 0,151 | 0,141 | 0,147 |
| PRT | 0,016 | 0,025 | 0,041 | 0,050 | 0,090 | 0,078 | 0,101 | 0,126 | 0,122 | 0,138 | 0,144 | 0,160 | 0,136 | 0,146 |
| SWE | 0,006 | 0,020 | 0,056 | 0,059 | 0,134 | 0,120 | 0,138 | 0,145 | 0,118 | 0,137 | 0,136 | 0,149 | 0,133 | 0,140 |
| ESP | 0,020 | 0,032 | 0,042 | 0,050 | 0,098 | 0,094 | 0,102 | 0,110 | 0,104 | 0,114 | 0,122 | 0,138 | 0,132 | 0,135 |
| **USA** | **0,030** | **0,045** | **0,093** | **0,066** | **0,068** | **0,067** | **0,073** | **0,088** | **0,091** | **0,093** | **0,102** | **0,116** | **0,104** | **0,127** |
| LTU | 0,000 | 0,005 | 0,025 | 0,051 | 0,104 | 0,099 | 0,119 | 0,123 | 0,102 | 0,113 | 0,113 | 0,125 | 0,112 | 0,119 |
| AUT | 0,012 | 0,014 | 0,024 | 0,036 | 0,072 | 0,066 | 0,082 | 0,085 | 0,084 | 0,092 | 0,087 | 0,103 | 0,094 | 0,099 |
| DNK | 0,011 | 0,025 | 0,079 | 0,047 | 0,070 | 0,071 | 0,073 | 0,068 | 0,068 | 0,076 | 0,083 | 0,092 | 0,085 | 0,091 |
| SVN | 0,000 | 0,013 | 0,019 | 0,033 | 0,038 | 0,039 | 0,051 | 0,053 | 0,052 | 0,063 | 0,072 | 0,084 | 0,080 | 0,084 |
| LVA | 0,000 | 0,005 | 0,013 | 0,022 | 0,050 | 0,053 | 0,063 | 0,073 | 0,071 | 0,081 | 0,083 | 0,095 | 0,083 | 0,084 |
| FIN | 0,007 | 0,017 | 0,048 | 0,061 | 0,097 | 0,092 | 0,106 | 0,089 | 0,087 | 0,087 | 0,084 | 0,085 | 0,061 | 0,073 |
| **FRA** | **0,013** | **0,023** | **0,020** | **0,026** | **0,046** | **0,048** | **0,048** | **0,054** | **0,050** | **0,058** | **0,059** | **0,067** | **0,062** | **0,067** |
| EU Core (ø) | 0,018 | 0,024 | 0,031 | 0,032 | 0,051 | 0,052 | 0,057 | 0,056 | 0,050 | 0,056 | 0,056 | 0,064 | 0,058 | 0,060 |
| **DEU** | **0,023** | **0,024** | **0,042** | **0,038** | **0,057** | **0,056** | **0,066** | **0,058** | **0,051** | **0,054** | **0,054** | **0,061** | **0,054** | **0,054** |
| ITA | 0,008 | 0,011 | 0,018 | 0,019 | 0,026 | 0,029 | 0,037 | 0,034 | 0,033 | 0,039 | 0,043 | 0,048 | 0,046 | 0,050 |
| GRC | 0,006 | 0,013 | 0,016 | 0,017 | 0,020 | 0,015 | 0,017 | 0,020 | 0,018 | 0,024 | 0,024 | 0,033 | 0,034 | 0,046 |

**Note:** Inward FDI Stock Intensity = Inward FDI Stock / Source Country Capital Stock. EU Core (ø) represents the unweighted average of France and Germany. 5-year intervals from 1990-2010, annual data thereafter. Capital stock at constant 2017 prices was converted into nominal values with the 2017 capital stock price level data from the same source.

**Source:** Own calculations and representation of FDI stock data from UNCTAD and capital stock data from the Penn World Table, version 10.0, Feenstra, Robert C., Robert Inklaar and Marcel P. Timmer (2015), "The Next Generation of the Penn World Table" American Economic Review, 105(10), 3150-3182, available for download at www.ggdc.net/pwt .

***International Capital Spillover Aspects and Effective FDI Stocks***

The above data might represent an underestimation of true FDI stock data if one considers the distinction between tangible and intangible capital; this distinction could be important in the context of an adequate assessment of the size of outward FDI stocks and inward FDI stocks: GRATTAN/PRESCOTT (2010) have developed such a model to study return differentials between foreign subsidiaries of US multinationals and US subsidiaries of foreign multinationals and point to measurement problems in the US national account concerning the measurement of intangible investment. A possible conclusion fromtheir work is that effective outward capital stocks of some OECD countries are much higher than official statistics suggest.

Multinational companies' foreign affiliates represent a specific part of the capita stock in host countries and profits accruing from affiliates to the source country will contribute to net factor income from abroad and hence the primary balance. Cumulated outward FDI should, following a standard view, indicate the share of the capital stock owned and used by foreign investors abroad – similarly, the same logic should apply to cumulated inward FDI; based on such FDI stock figures it should be possible to calculate with relative ease the relevant rates of return for foreign investment, say for foreign affiliates in the US and for US subsidiaries in the rest of the world. Reality, however, is more complicated as emphasized by GRATTAN/PRESCOTT (2010) who point out that not only international risk premium effects could matter – as in the standard view of international profits from foreign affiliates – but that there could also be a particular distorting role played by intangible capital (e.g., technology that can be used in many locations) of for plant-specific outward investment: technology is often a non-rival good and the accounting figures available in the System of National Accounts do not give full and easy access to effective capital stock figures, particularly if one considers intangible capital and technology input, respectively. If, for example, one would know exactly the implicit and explicit exports of headquarter services to subsidiaries abroad in the field of intangible capital, one would often find that the effective outward FDI capital stock is higher than standard accounting figures suggest. Therefore, the rather high differential between the US rate of return on equity for outward FDI and the rather modest rate of return on foreign affiliates in the US might be reduced to a smaller number once the true outward FDI stock of US firms is taken into account – this is a main point of the analysis of Grattan and Prescott, including a simulation analysis, for the US outward and inward FDI (the intangible capital investment of foreign investors in the US is also underestimated in standard BEA statistics, but it seems that the US' intangible capital investment abroad is relatively high compared to foreign intangible investment in the US).

GRATTAN/PRESCOTT (2010) argue that the BEA data regarding return on investment of foreign subsidiaries of US MNCs in 1982-2006 averaged 9.4 percent annually after taxation, while US subsidiaries of foreign MNCs achieved a modest 3.2 percent. The authors write (p. 1493):

*"BEA returns on foreign direct investment (FDI) are distorted because most intangible investments made by multinationals are expensed… the differences in these returns are not only high on average but are persistently high…We estimate that mismeasurement of intangible investments accounts for over 60 percent of the difference in BEA returns… Furthermore, when compared with estimates of returns of US businesses on domestic operations, returns on*

*investments abroad are 4 to 5 percentage points higher, and returns on investments made by foreign companies in the United States are 1 to 2 percentage points lower…[There is..] technology capital that can be used at multiple locations and intangible capital that is plant specific. Examples of technology capital include accumulated know-how from investments in research and development (R&D), brands, and organizations that is not specific to a plant. Technology capital used abroad generates rents for foreign subsidiaries with no foreign direct investment. Thus, given technology capital, foreign subsidiaries play an essential role."*

As regards the above quote, one further conclusion which could be drawn is that the considerable mismeasurement of international profit rates' imply that effective outward capital stocks of some OECD countries are much higher than official statistics suggest. The standard BEA analysis gives the following Table A5 if one compares the profit income ratio of foreign subsidiaries in the United States – profits relative to GDP (column (2)) – with the US profits from subsidiaries abroad which is a useful element to understand the overall current account changes: relative to US GDP, one clearly finds that the US FDI profit balance is positive in the period 2010-18; with a long-term tendency to reduce with respect to the US FDI net profit balance relative to the US GDP. The US primary income balance is positive in a long run perspective. This is an interesting finding for the net US FDI profit ratio with the US representing the largest FDI source economy and the largest global FDI host country – except for China. The FDI profit shares in columns (1) and (2) reflect differential rates of return for US inward FDI and US outward FDI on the one hand; with a higher rate of product innovations and process innovations both potentially contributing to a higher rate of return on equity. On the other hand, multinationals' capital accumulation effects in the US and outside of the US – both concerning subsidiaries – are crucial elements for the US FDI net profit balance relative to US GDP.

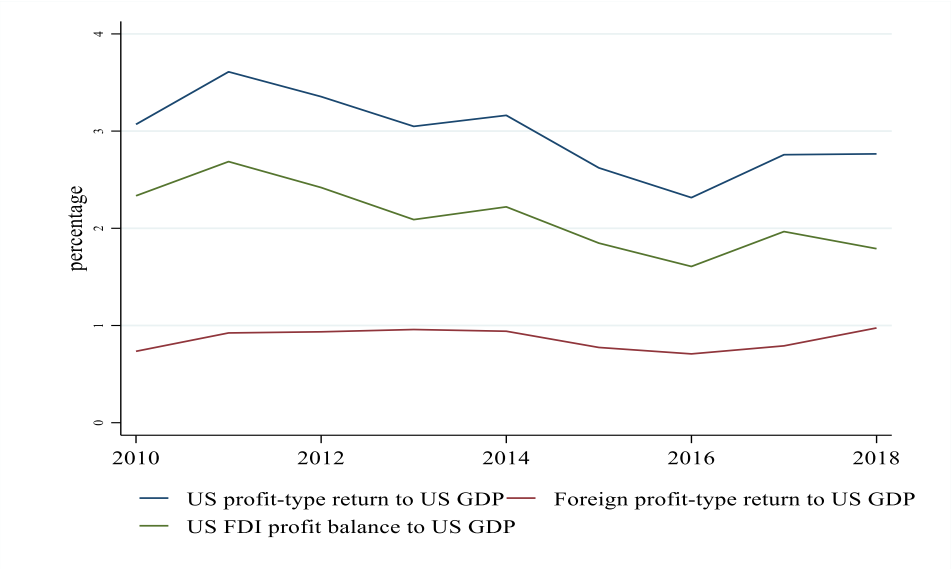
**Table A5: Profit Income Ratio of US Subsidiaries Abroad (Column 1) and Profit Income Ratio of Foreign Subsidiaries in the US (Column 2) as well as US Net FDI Income Ratio (Column 3)**

| | (1) | (2) | (3) |
|---|---|---|---|
| Year | US profit-type return relative to US GDP | Foreign profit-type return relative to US GDP | US FDI profit balance relative to US GDP<br>(1) - (2) |
| 2010 | 3.069 | 0.735 | 2.335 |
| 2011 | 3.610 | 0.924 | 2.686 |
| 2012 | 3.355 | 0.935 | 2.419 |
| 2013 | 3.049 | 0.959 | 2.090 |
| 2014 | 3.162 | 0.941 | 2.221 |
| 2015 | 2.622 | 0.774 | 1.848 |
| 2016 | 2.316 | 0.708 | 1.608 |
| 2017 | 2.757 | 0.791 | 1.967 |
| 2018 | 2.766 | 0.975 | 1.791 |

*Note: Here we follow the discussion in TØRSLØV/WIER/ZUCMAN (2020) to use the "profit-type return" in the BEA Value Added tables instead of "net income" to avoid double-counting profits. The profits of US affiliations abroad have been taken from the USDIA VA tables (F1-F9), the relative ratio to US GDP is reported in column (1). The profits made by foreign affiliations in the US have been taken from the FDIUS VA tables (F1-F6), the relative ratio to US GDP is reported in column (2).*

*Source: Own representation of data available from the BEA https://www.bea.gov/international/di1fdiop*

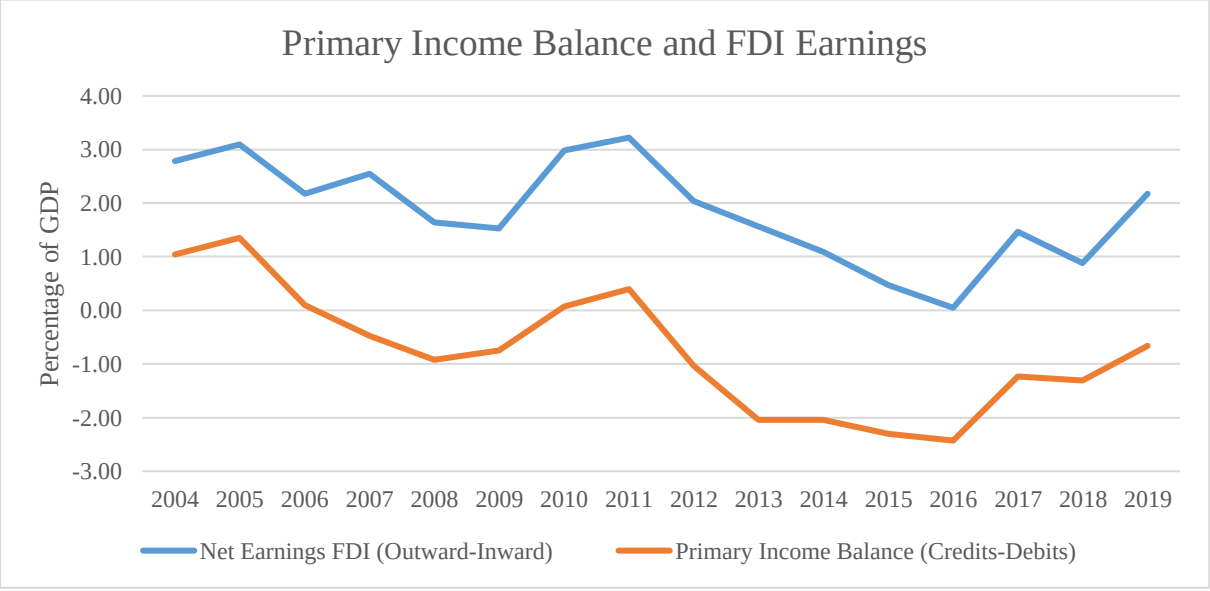
**Figure A1: Profit Income Ratio of US Subsidiaries Abroad and Profit Income Ratio of Foreign Subsidiaries in the US as well as US Net FDI Income Ratio**




*Source: Own representation of data contained in Table A5 which is based on data from the BEA*

As regards the primary balance – relative to GDP – and the sub-item of the net FDI income balance, one may point out that changes in the primary balance in major OECD countries to some extent are driven by changes in the net FDI income balance. This balance can be rather high as shown in the subsequent graphs for the UK, Germany and the US; the swing in the net FDI profit balance has reached about 2 percent of GDP in the UK between 2011 and 2016 and this has driven down the primary income balance almost in parallel (Fig. A2).

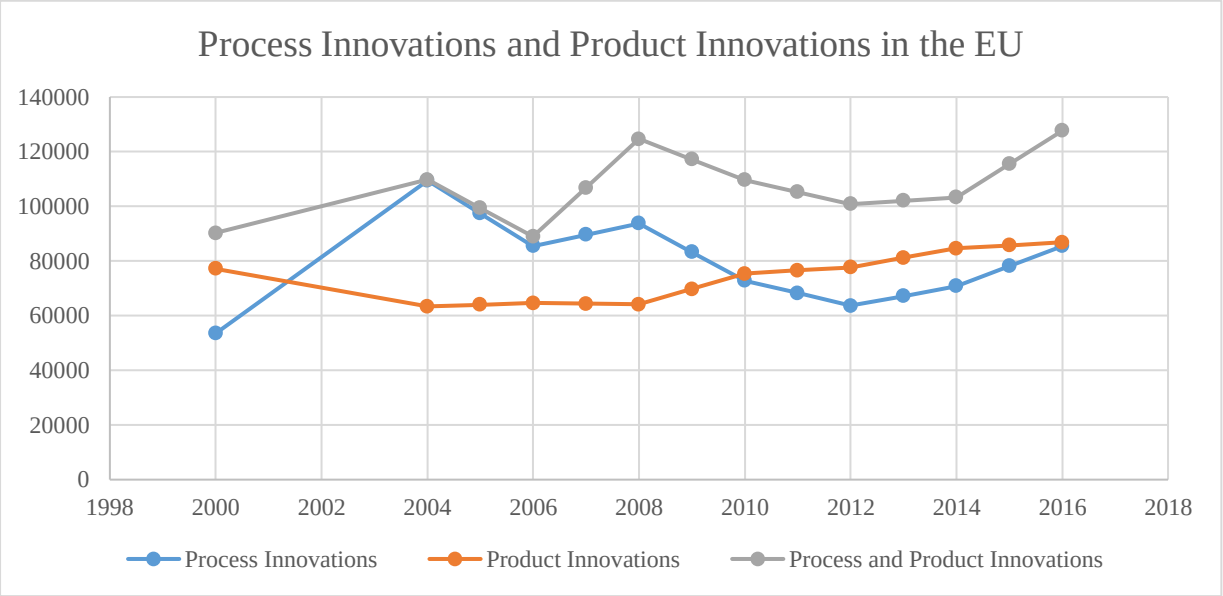
**Figure A2: Net FDI Profit Balance and Primary Income Balance in the UK, 2004-19**




*Source: Own representation of data available from OECDStat on primary income balances, and data on UK FDI earnings from the Office for National Statistics releases from 2015-2020 on FDI involving UK companies*

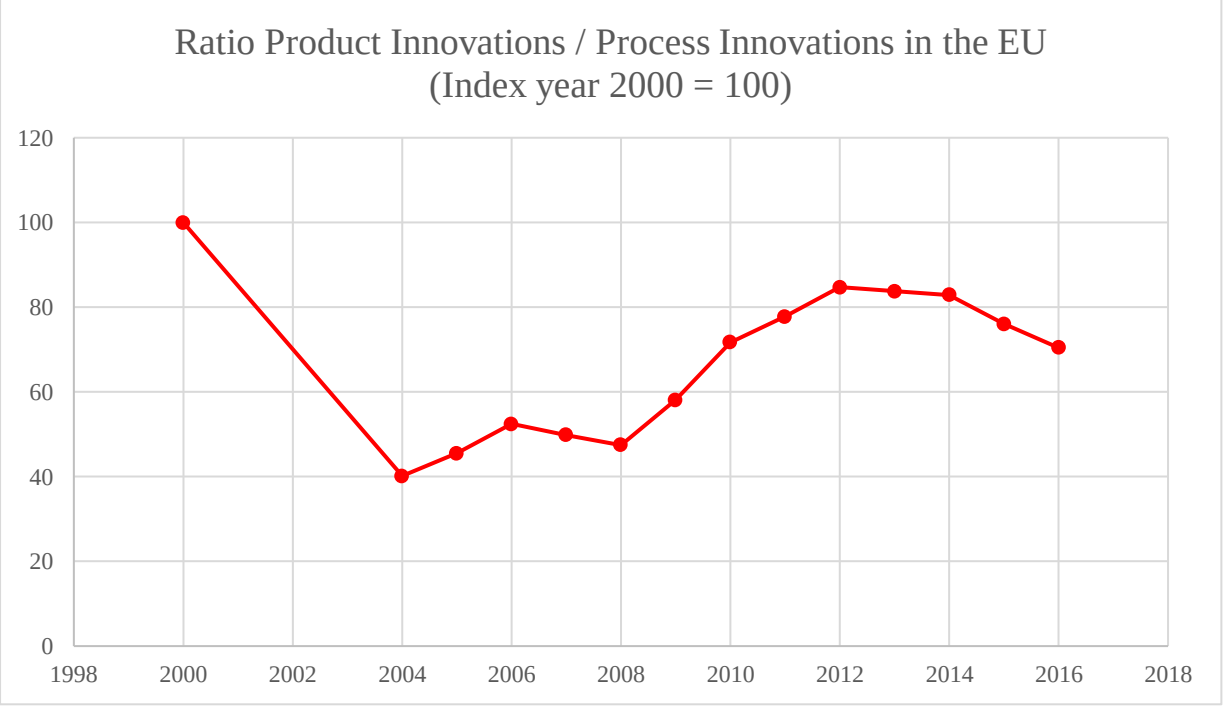
# Appendix B: Results from the EU Community Innovation Survey

**Figure B1: Major Companies in the EU: Process Innovations, Product Innovations and Firms with both Process and Product Innovations in the EU (aggregate; based on the EU Community Innovation Survey; with interpolation for years without a survey), 2000-2016**




*Source: Own representation and calculations based on data from EU Community Innovation Survey*

**Figure B2: Ratio of Product Innovations to Process Innovations in the EU, 2000-2016 (aggregate date; year 2000: index normalized to 100)**




*Source: Own representation and calculations based on data from EU Community Innovation Survey*

# Appendix C: Product Innovation

**Product innovation**

We follow the literature on endogenous growth and model product innovation as an increase in the variety of goods produced in sector 1 and/or 2. An increase in variety can be mapped into our sector demand functions.

Domestic firms offer $n^D$ domestic varieties foreign firms offer $n^F$ foreign varieties

$$C_t^c = \left[\sum_i^{n^d} C_{i,t}^{c,d\frac{\sigma-1}{\sigma}} + \sum_i^{n^f} M_{i,t}^{c\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad \text{(A1.1)}$$

And assuming symmetry

$$C_t^c = \left[n^d C_{i,t}^{c,d\frac{\sigma-1}{\sigma}} + n^f M_{i,t}^{c\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad \text{(A1.2)}$$

Demand for a single domestic variety

$$\frac{\partial C_t^c}{\partial C_{i,t}^{c,d}} => C_{i,t}^{c,d} = \left(\frac{PC_t^c}{P_{i,t}^c}\right)^{\sigma} C_t^c \quad \text{(A2)}$$

Demand for a single foreign variety

$$\frac{\partial C_t^c}{\partial M_{i,t}^c} => M_{i,t}^c = \left(\frac{PC_t^c}{P_{i,t}^M}\right)^{\sigma} C_t^c \quad \text{(A3)}$$

Total domestic consumption of domestic goods (under symmetry)

$$C_t^{c,d} = n^d C_{i,t}^{c,d} \quad \text{(A4)}$$

Total demand for imports

$$M_t^c = n^f M_{i,t}^c \quad \text{(A5)}$$

Now we can rewrite the utility function (A1) in terms of domestic and foreign aggregates

$$C_t^c = \left[n^{d\frac{1}{\sigma}} C_t^{c,d\frac{\sigma-1}{\sigma}} + n^{f\frac{1}{\sigma}} M_t^{c\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad \text{(A6)}$$

And we can interpret the share parameters as index for the number of varieties.

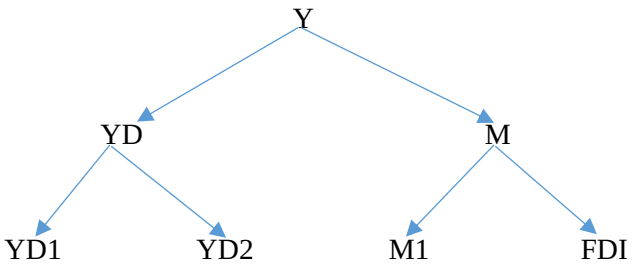
Apart from the share parameter in den in the demand function for domestic goods and imports, a product innovation also affects the ideal price index, which is an argument in the demand function. The ideal price index can be obtained by substituting the demand functions into the utility function. As can be seen from (A7) is also a function of the number of varieties.

$$PC_t^c = \left[n^d \left(P_{i,t}^c\right)^{1-\sigma} + n^f \left(P_{i,t}^M\right)^{1-\rho}\right]^{\frac{1}{1-\sigma}} \quad \text{(A7)}$$

# Appendix D: Preference Structure

In this paper we assume the following structure of preferences of consumers and investors

**Figure D1: Structure of preferences in the paper**



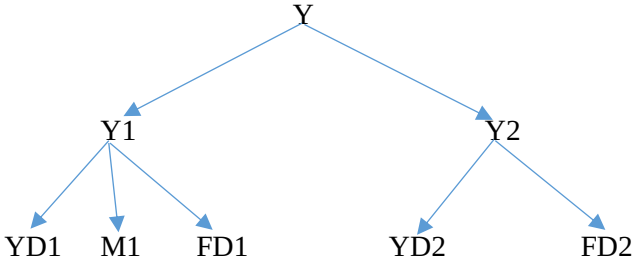

*Source: Own representation*

and we impose an EoS between the import/FDI aggregate which is larger than one. An EoS larger than one between domestic goods and imports is consistent with empirical estimates (see BOEHM ET AL., 2019). Unfortunately, there is no direct empirical evidence on the EoS between an import/FDI aggregate and domestic goods. In this section, we will argue that it is plausible to assume an elasticity larger than one also for this case. Our argument is based on the following considerations. In a more disaggregated model one could distinguish between FDI in the tradables and the non-tradables sector (see Figure D2).

The left branch of Figure D2 shows possible interactions between FDI and traditional tradables (e.g., manufacturing). Examples of high EoS between FDI1 and Y1 would be the FDI activities of car producing MNCs and domestic multinationals.

The right branch of Figure D2 shows possible interactions between FDI and domestic non-tradables. Examples of high EoS between FDI2 and Y2 would be foreign multinational banks operating in the domestic economy, offering highly substitutable financial services. In the retail sector also (which is historically non-tradable), FDI producers (e.g., Amazon) are increasingly competing with domestic retailers.

**Figure D2: An alternative preference structure**




*Source: Own representation*

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