Revisiting the brain drain literature with insights from a general equilibrium world model *

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Abstract

The existing brain drain literature has found various mechanisms through which the high-skilled South-to-North migration affects developing economies. However, some of the newfound effects remain disputable due to limited evidence. This paper aims to provide suggestive guidelines for future research by identifying the mechanisms that can generate larger economic impacts at the aggregate. The analysis is based on a dynamic general equilibrium world model that is calibrated to published statistics and incorporates empirical estimates on the effects of brain drain. It simulates short- and long-run impacts of increased brain drain on GDP per capita, GNI per capita, and income inequality. The results suggest that more studies be conducted to further examine how the brain drain influences human capital formation and technology spillovers. Both have significant impacts on domestic production and national income. A better understanding of different remitting patterns is also desirable because it can affect income inequality to a large degree.

Keywords: Brain drain, Human Capital, Remittances, Networks Externalities, Development.

JEL Codes: F22, J24, O15.

*The views expressed in this paper are those of the authors and do not necessarily reflect those of the Central Bank of Luxembourg nor of the South Coast Air Quality Management District.
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1 Introduction

The South-to-North migration of talented workers is a key phenomenon over past decades. The number of highly educated immigrants living in the OECD countries has grown by 70 percent during the 1990s, more than twice the growth rate for less educated immigrants. Importantly, two-thirds of this increase in skill inflow came from developing countries (Docquier et al., 2009). As these countries generally have lower levels of human capital to begin with, the brain drain issue is expectedly at the forefront of their concerns.

The early literature in the 1970s examined only the direct negative effects of brain drain on those left behind in the home countries, thus leading to uniformly pessimistic assessments (e.g. Bhagwati and Hamada, 1974; McCulloch and Yellen, 1975, 1977). The more recent studies, however, began to recognize that the brain drain could in effect have positive influences on economic development back home. These include the ex-ante effect that induces more investment in education (so as to maximize individual probability to emigrate and benefit from higher wages abroad), as well as a list of ex-post feedback effects such as remittances, return migration embodied with additional knowledge and skills acquired abroad, and the creation of business, political, and scientific networks (Docquier and Rapoport, 2012).

The aim of this paper is to provide suggestive guidelines for future research by identifying the brain drain mechanisms that, based on currently available evidence, can generate larger economic impacts at the aggregate and thus potentially have significant policy implications. We focus on the brain drain effects that have been found in the existing literature but whose magnitudes and validity remain disputable. This is either due to a limited number of studies that have been conducted or because of the confinement of data quality used in the research. In some cases in particular, the estimated effects must be considered as preliminary, since it is hard to establish key mechanisms and causality in cross-sectional empirical studies.

This paper incorporates four such brain drain effects that can be ultimately channeled through the migrants home economy and produce macroeconomic impacts that affect the welfare of those who remain in the origin country. They include the incentive effect on educational investment (labeled ‘incentive effect’), migrants remittances (labeled ‘remittances’), network externality on technology transfer (labeled ‘TFP externality’), and network externality on foreign direct investment (labeled ‘FDI externality’). A short description of each of these four channels can be found in Table 1. Their relative impacts are examined on the measures of GDP per capita, GNI per capita, and income inequality.

Our analysis uses the multi-region general equilibrium model of the world economy constructed in Marchiori, Shen and Docquier (2013), where the global impact of increased brain drain on GDP per capita is simulated. The model is characterized by an overlapping-generations (OLG) dynamics with heterogeneously skilled workers. It is calibrated to published statistics, and most importantly, incorporates currently available empirical evidence.
Table 1: Four major brain drain effects considered

<table>
<thead>
<tr>
<th>Brain drain channel</th>
<th>Description</th>
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<tbody>
<tr>
<td>Incentive effect</td>
<td>Better migration prospects for the highly educated stimulates more human capital formation at the origin country.</td>
</tr>
<tr>
<td>Migrants’ remittances</td>
<td>Migrants remit money earned in the destination country back to the origin country.</td>
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<tr>
<td>TFP externality</td>
<td>Brain drain facilitates the origin country’s adoption of the more advanced technologies that have been developed in the destination country.</td>
</tr>
<tr>
<td>FDI externality</td>
<td>Brain drain facilitates FDI inflows to the origin country because it enhances foreign investors’ knowledge about the origin country, thus reducing transaction costs and investment risks.</td>
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</table>

of the brain drain. Starting from the framework in Marchiori, Shen and Docquier (2013), we assess the relative impact of each of the four specific channels by switching off each of them alternately. This way, we observe the changes in aggregate economic outcomes as if one empirically identified brain drain effect were null. Assessing the relative impacts on GNI per capita and income inequality, on top of GDP per capita, adds additional values. It allows us, for instance, to refer to the literature studying the impact of remittances receipts in migrants’ origin countries.

Overall, we find that:

- The incentive effect, which induces individuals to invest more in education, can produce large macroeconomic impacts in migrants’ origin country. When the empirically estimated incentive effect on human capital formation is absent in the simulation, economies in all the migrant sending regions become very much worse off in the long-run. This is because, first, the economy has less effective units of labor, and second, the economy has less skilled workers who are capable of absorbing and adopting advanced technologies. The incentive effect also greatly affects high-to-low skilled income inequality. Without it, the growing scarcity of skilled workers leads to higher skill wage premium, thus widening the income gap in all developing regions.

- The TFP externality affects an economy’s production efficiency and the global allocation of production factors. The main beneficiary of this effect is the least developed part of the world that has experienced mild brain drain. In the simulation when the TFP externality is removed, domestic production and national income are significantly
reduced in those developing countries that are far from the technological frontier. It is as if we assume that migrants’ diaspora does not help diffuse advanced technologies from the North to the South. Without this effect, these developing countries would have a harder time attracting foreign investment. Capital investment from the North would largely remain in other developing countries that are closer to the technology frontier and less reliant on technology adoption.

- **Remittances** from high-skilled migrants play an important role in subsidizing the income of those remain in the home country. Moreover, when some portion of remittances receipts are converted into savings and invested in the following periods, it creates the dynamic effect that can further elevate national income in the developing country. That is why, in the simulation when the high-skilled have a lower propensity to remit than their low-skilled counterparts do, all the developing regions are negatively affected in terms of GNI per capita.

- The **FDI externality** is found to have a limited positive impact at the aggregate level of the economy. In the simulation, the absence of the FDI externality only slightly affects migrants’ origin country in terms of all economic indicators. This indicates that, even though migrant networks enhanced the knowledge of foreign investors about migrants’ origin country and helped them navigate the local system better, it is however the underlying infrastructure such as TFP and the availability of skilled workers that matter the most in attracting FDI.

- In light of the results above, we argue that it is of primary importance for future research on the brain drain to verify the validity and the magnitude of the incentive effect on human capital formation. Its importance also lies in its connectivity with the TFP externality, as technology adoption would not be viable if there is not a large enough pool of skilled workers remaining in the origin country. In addition to further examining the technology transfer channel, more research is also needed to better understand other potential mechanisms through which high-skilled emigration can affect total factor productivity.

Regarding remittances, it is still an unsettling issue whether high-skilled migrants, when compared to their less-skilled counterparts, send home a higher or lower proportion of their income. However, in terms of economic development per se, it is arguably more important that high-skilled migrants remit more in absolute terms (Bollard et al. (2011) puts forward confirmative evidence). Our results shed further lights on the importance to study the allocation of remittances. It is crucial to analyze how remittances affect the recipients household budgeting, in particular the amount invested in productive assets, as it has dynamic income effects as well as profound implications on current and future.
Finally, our results show a very modest positive impact attributable to FDI externality. However, the single-sector model may have masked the importance of this effect for certain industries, especially those that are capital intensive. Thus, we recommend that further studies on the FDI externality to differentiate the effect at the sectoral level.

The rest of the paper is organized as follows. Section 2 describes the methodology and Section 3 briefly presents the total impacts of all the brain drain channels on sending economies. Section 4 provides some insights for future research by discussing the literature of each brain drain channel in light of the specific impact of each channel. Section 5 concludes.

2 The general equilibrium framework

The objective of using the general equilibrium framework is to analyze the impact of a 20 percent increase of the forecasted flows of high-skilled migrants from every developing region to each developed region on GDP per capita, GNI per capita and high-to-low skilled income inequality of the developing regions. The shocks occur between 2010-20 to 2050-60. The analysis is based on an overlapping-generations (OLG) model with high-skilled and low-skilled workers, where the world is divided in ten regions (three developed and seven developing regions), according mainly to geographical and demographic criteria. In the baseline scenario, an original back-solving calibration method, that allows to exactly match the observed world disparities between and within regions, is used.

Each region has three types of agents: households, firms and the public sector. The adult population is divided into 8 overlapping generations, from age 15-24 to age 85-94. Age is denoted by $a = 0, \ldots, 7$. Individuals have uncertain lifetime and can die at the end of every period. In each generation, we have time-varying proportions of low-skilled and high-skilled individuals. Due to data availability constraints, the high-skilled are those with post-secondary education completed.

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1We distinguish three developed regions, North America (NAM), Japan (JAP) and other high-income OECD countries (ADV). The latter group is essentially made up of European Union countries but also comprises Australia and New Zealand. We distinguish seven developing regions, Eastern Europe (EAS), Middle East and Northern Africa (MEN), Latin America and the Caribbean (LAC), Sub-Saharan Africa (SSA), the Former Soviet Union (RUS), the Chinese world (CHI) and the Indian world (IND). The detailed list of countries by region can be found in Table 3 of the appendix.

2The model has two main blocks with a recursive structure. In order to account for the empirical elasticities estimated in the literature, an ‘upstream block’is calibrated outside the core of the model using data and empirical studies. This block predicts the evolution of demographic variables, human capital and the magnitude of diaspora externalities. Then, these predictions are introduced in a ‘micro-founded general equilibrium block’ which generates predictions for the world output, prices, remittances, asset accumulation, the geographical allocation of assets, the international flows of capital income and many other endogenous variables. The model and calibration are based and detailed on Marchiori et al. (2013). This section provides only the essential elements of the model structure.
Migration occurs at the first period of life and is permanent. This is a realistic assumption since we focus here on the migration of high-skilled workers, who are most likely to emigrate on a more permanent basis with their family members. We only track migrants from the South to the North. Other international migrants are included in the demographic forecasts.

Migrants remit a fraction of their consumption. This proportion is calibrated considering the officially recorded remittances to GDP ratio for each developing region. Moreover, it is assumed at the baseline, that high-skilled migrants have the same propensity to remit than low-skilled migrants and that remittances are distributed equally among all residents living in the same developing region.

The production process of the firms in each region is characterized by a constant elasticity of substitution (CES) transformation function for efficient labor, which defines the mix of high-skilled and low-skilled workers to produce an homogeneous good. The parameters of the production process are dynamically calibrated in order to match the income disparities between and within the regions (i.e. distance to the technological frontier and skill premium).

The government levies taxes on labor earnings and on consumption expenditures in order to finance general public consumption, pension benefits and other welfare transfers. The government also issues bonds and pays interests on public debt.

The government’s budget constraint is satisfied at each period by adjusting the wage tax rate.

Finally, in the economy there is perfect capital mobility and a competitive equilibrium is characterized by (i) households’ and firms’ first order conditions, (ii) market-clearing conditions on the goods and labor markets, (iii) budget balance for each regional government, (iv) the equality between the aggregate quantity of world assets and the quantity of the world capital stock plus the sum of public debts of all regions, and finally (v) the arbitrage condition of the rates of return to capital, given region-specific risk premia. The equilibrium on the goods market is achieved by Walras’ law.

3 Interpretation of simulated results

This section describes the shocks and indicators we look at, before presenting the general results where all the considered mechanisms impact on the sending countries. (Disentangled results are discussed in Section 4.)

3.1 Shock description

Our period of interest is 2000-2100, or the year before the first wave of additional migrants in the developed regions to the year when the last wave is entirely retired. We pay special attention to year 2060, or when the first wave of migrants is fully retired and the last wave fully joins the workforce. Starting from the U.N. forecasts, in each decennial period from
2010-20 to 2050-60, the demographic shock constitutes a 20 percent increase in the forecast flow of high-skilled migrants from every developing region to each developed region. Their allocation by destination region is assumed to be identical to the one observed in 2000. Such a change could be due to increasingly selective immigration policies at destination. It has to be noticed that migration shock has only transitory effects. Since the migratory shock is performed until 2050 and individuals live for 8 periods, the effects last only until the end of the century, i.e. when the last wave of additional migrants has retired.

The assessment of the overall impacts is conducted by comparing three economic indicators at the baseline and after shocks. These indicators are defined as follows:

- **GDP per capita:** total domestic production divided by total population, $\frac{Y_t}{N_t}$.
- **GNI per capita:** $GNI_t/N_t$, where $GNI_t = Y_t + \text{remittance receipts}_t + \text{net capital income inflows}_t + \text{foreign aid}_t$.
- **High-to-low skilled income inequality:** ratio of high-skilled to low-skilled GNI per capita, $(GNI^h_t/N^h_t)/(GNI^l_t/N^l_t)$.

The indicators above are affected by the shock of additional high-skilled emigration through four different channels:

- **Human capital:** in the model incentive effects on investment in education at origin are incorporated following Beine et al. (2008), where gross (pre-migration) human capital levels depend on high-skilled emigration rates. The effect of increased high-skilled emigration may either enhance or deteriorate the level of human capital, depending on the calibrated elasticities of natives’ human capital to the high-skilled emigration rate.
- **Remittances:** in the model remittances enter the migrants’ utility function that is a weighted combination of goods consumption and remittances. The weights are given by migrants’ propensity to remit, which in the baseline are assumed to be equal between skill types. Moreover, it is assumed that remittances are distributed equally among all residents living in the same developing region.
- **Technological progress:** in the model an endogenous Harrod-neutral technical progress of the neo-Schumpeterian type is considered. Technical changes are determined by the regional capacity to innovate and to adopt modern technologies. high-skilled emigrants

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3Net capital income inflows are calculated as the value of residents’ assets subtracted by the returns to capital used in domestic production.

4The definition of $GNI^j_t$, $j = \{s, l\}$, is analogous to $GNI_t$, except that (residents’ labor income$_t^j +$ residents’ asset value$_t^j$) is used in place of $Y_t$.

5In our simulations, demographic changes also affect the economic performances of the economy through the support ratio, defined as the ratio of labor force to population, but here we do not focus on them.

6The calibration propensity to remit is based on the officially recorded remittances to GDP ratio for each developing region.
living in rich countries, increase the capacity to adopt modern technologies. Following Lodigiani (2008), it is assumed that resident high-skilled workers has an enhancing effect for growth in economies closer to the frontier, where innovation is more important, while high-skilled emigration has a decreasing effect on growth when a country approaches the frontier. Conversely, backward countries, that rely more on adoption, can benefit from high-skilled diaspora as it facilitates technology and knowledge transfer from abroad. Since our shock modifies human capital and the number of high-skilled emigrants abroad, it affects the rate of technical progress as well. The effect will be positive or negative according to the region’s relative distance to the technological frontier.

- Risk premium/information costs: in the model, physical capital is assumed to be mobile across regions, and the optimal marginal productivity of capital is equal to the international interest rates augmented by the region-specific risk premium, which reflects informational costs or risks. High-skilled diaspora may contribute to reducing information-related risks for capital investments in the migrants’ home countries, and thus attracting more FDI inflows in the South. 7

To begin with, we consider the total impacts on GDP and GNI per capita, as well as on high-to-low skilled income inequality.8

3.2 Total impact results

GDP per capita. Figure 1.a presents the total impacts of the selective immigration policy on GDP per capita. In the short-run, the overall effect is positive for some developing regions (i.e., MEN, RUS, IND, with 0.3-0.6% increases in 2060), while others have to first undergo long periods of economic downturn along the transitional path (i.e., EAS, LAC, SSA, and CHI, with 0.4-0.7% decreases in 2060). However, in the medium-to-long term, all the seven developing regions either experience increased GDP per capita or encounter a very slightly decrease.

GNI per capita. The total impacts of the demographic shock on GNI per capita are depicted in Figure 1.b. Compared to the total impacts on GDP per capita, the general picture is slightly more optimistic. While the short-run winners and losers remain the same, the magnitudes of negative impacts are decreased (from 0.4-0.7% to 0.1-0.5% in 2060) whereas the scale of positive impacts are increased (from 0.3-0.6% to 0.6-0.8% in 2060). Recall from the definition of GNI that it comprises of domestic outputs, remittances receipts, residents’ foreign assets, and so on. Hence, the similar patterns between the total impacts on GNI per capita and on GDP per capita suggest that the channels at work are the same as for GDP per

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7 Calibration of FDI externalities is based on Docquier and Lodigiani (2010) estimations.
8 Figures in the text illustrate our main results.
Figure 1: Total impacts

a. Effect on GDP per capita

b. Effect on GNI per capita

c. Effect on High-to-Low Skilled Inequality
capita, except that remittance receipts, which have a dynamic effect to raise residents’ assets via saving, also come into play and act to improve the welfare of those left behind.

**High-to-Low Skilled Income Inequality.** Since brain drain does not only impact the overall economic outcome but also entails distributional effects, it is important to study how the high-to-low skilled income inequality is affected by the migration shocks. Figure 1.c depicts the total impacts with the usual calibration. In the short-run, income inequality decreases in all the seven developing regions (by 0.6-1.8% in 2060) and continues to decrease in the medium-to-long term.

4 Individual channels and related literature

In the previous section, we assessed the total impacts of a selective immigration policy on the three considered economic indicators. As previously noticed, these indicators are affected by the shock of additional high-skilled emigration through different channels, in particular human capital, remittances, technological progress, and risk premium/information costs. This section aims to understand which are the dominant channels at work and under which conditions they induce positive or negative effects on developing regions. In order to do so, we run alternative simulations abstracting from each channels by turns. We then compare the effects of major brain drain channels (including human capital formation, remittances, technology spillovers, information favoring foreign investment) on GDP per capita, GNI per capita and high-to-low skilled income inequality with respect to the total impacts as in section 3.2. By identifying the relative force of each channel, we can provide some suggestions on the channels that should be further investigated. In the next paragraphs we present the existing literature, our results, and specific recommendations on each brain drain channel.

4.1 The incentive effect (on education)

**The incentive effect - Literature**

The *incentive effect* on education was put forward in the seminal papers of the new brain drain literature, which has emerged since the mid-90’s. It shows that increased migration prospects for the high-skilled could stimulate more human capital formation, thanks to higher expected returns to education (see for example, the theoretical works of Mountford, 1997; Stark and Wang, 2002; Stark et al., 1997, 1998; Stark, 2004; Vidal, 1998, and for empirical evidence Beine et al., 2001, 2008, 2010).

This ”new” literature was in contrast with the more traditional one on the implications of the brain drain for sending countries, which emphasized the negative effects of high-skilled migration for the sending countries (Bhagwati and Hamada, 1974), and that was re-considered in an endogenous growth framework at early 90’s. Since human capital accumulation is
important in inducing economic growth (Lucas, 1988), the loss in human capital induced by the emigration of high-skilled workers would have reduced productivity and income per capita, therefore restraining growth in the sending country (Miyagiwa, 1991; Haque and Kim, 1995).

The new recent literature offered a more optimistic perspective (Mountford, 1997; Stark and Wang, 2002; Stark et al., 1997, 1998; Stark, 2004; Vidal, 1998). The main insight of these studies is that on an individual level, migration prospects increase the expected return of education in poor countries and therefore foster domestic enrollment in education. When this incentive (or 'brain') effect dominates the observed emigration (or 'drain') effect, the origin country may in fact end up with more human capital. One of the main assumptions of these models is that the probability of migration is uncertain: among the many that invest in education, only a fraction actually emigrates. Those who remain in the country are endowed with higher human capital thanks to the incentive effect. At the empirical level, an important step in the literature has been taken by Beine et al. (2001). In a cross-sectional study of 37 developing countries, they show that the probability of emigration has a positive impact on human capital formation in sending countries, especially for countries with a low initial GDP per capita level. Results were confirmed by Beine et al. (2008), when using comparable high-skilled emigration rates as computed in the comprehensive Docquier and Marfouk (2006) dataset in a cross-sectional analysis of 127 developing countries. The results also hold using Beine et al. (2007)’s alternative brain drain estimates when controlling for where migrants acquired their skills, different definitions of human capital and functional forms (Beine et al., 2010). Given the cross sectional nature of the data of previous studies, to further assess the robustness of the results and to control for unobserved heterogeneity across countries, Beine et al. (2011) estimate a similar equation in a panel setting using Defoort-Oden (2008) ’s data set. Their results confirm a significant incentive effect on developing countries with a stronger effect for low-income countries. More specifically, counterfactual exercises show that the winners (countries which may experience an increase in post-migration human capital stocks) are the ones combining low levels of human capital and low rates of high-skilled (e)migration (Beine et al., 2008; Docquier and Rapoport, 2012).

Despite this evidence, the positive impact of migration prospects on human capital formation (the so-called “incentive effect”) is still questioned by several authors. Faini (2003), for example, finds little empirical support of a positive effect of the brain drain on the educational achievements in the home country. Schiff (2006) theoretically shows that the size of the brain gain and its impact on welfare and growth are significantly smaller than what found in the new brain drain literature. He concludes that the effect of brain gain is negative or, at best, slightly positive. On the other hand, positive evidence of incentive effects on education is confirmed also by some studies at the micro level (Batista et al., 2012; Gibson and McKenzie, 2011).
The incentive effect - Results

Our study confirms the sizable effect of high-skilled migration prospects on human capital formation in developing countries, both in terms of GDP/GNI per capita, and in terms of high-to-low skilled income inequality. In Figure 2, we run an alternative simulation where we abstract from the incentive effect on human capital formation. The total impacts on GDP per capita (Figure 2.a to be compared with Figure 1.a) are far more pessimistic, with all regions benefiting less/ suffering more from the migration shocks (with 0.0-0.3% increases and 0.3-2.1% decreases in 2060). In 2060, CHI, RUS, LAC and EAS are the most suffering regions, with a large negative impact on GDP per capita. In particular, for RUS the positive total effects on GDP per capita turn out to be negative. The long-term effect of the brain drain would be substantially worse without the incentive effect. In 2100, only MEN and IND remain as the beneficiaries in terms of GDP per capita. In addition, EAS, LAC, SSA, and CHI are now faced with non-negligibly negative impacts even in the medium-to-long run, which range between 0.3-1.5% in 2100. Similar results are obtained when we consider the GNI indicator as in Figure 2.b.

Consistent with the model where high-skilled and low-skilled labor are imperfect substitutes, and therefore the skilled composition of human capital leads to changes in the skill premium, the total impacts on inequality is strongly influenced by the human capital channel. This is specifically shown in the alternative scenario that lacks the incentive effect on human capital formation: in Figure 2.c, all developing regions experience strong rising income inequality (by 0.2-1.0% in 2060) due to larger skill outflows, which is in contrary to all other scenarios where “brain gain” eventually leads to a smaller income gap between skill types.

The incentive effect - State of the art

Despite the controversies in the literature, in this study ”incentive effects” on human capital formation play an important role both in terms of production and inequality. Even if issues on this channel have been quite extensively investigated and debated by the literature (e.g. Faini, 2003; Beine et al., 2008, 2010, 2011), there is certainly room for improvement in the identification of these effects. As it is well-known, cross-sectional studies (e.g. Faini, 2003; Beine et al., 2008, 2010) suffer from a lot of shortcomings (e.g., omitted variables and impossibility to control for unobserved heterogeneity). In order to obtain more accurate results, an analysis in a panel setting using a more sophisticated econometric method, as in Beine et al. (2011), is required. Unfortunately, this study still suffers from poor data quality on migration (the data consist only of six destination countries and many data points are the results of interpolation). It would be interesting to see whether consistent results can be obtained once new data with a longer period of time and with more destination countries become available.
Figure 2: Lack of incentive effect

(a. Effect on GDP per capita)

(b. Effect on GNI per capita)

(c. Effect on High-to-Low Skilled Inequality)
## 4.2 Remittances

### Remittances - Literature

Remittances increased strongly during the last decades, becoming an important source of funds for many developing countries. Remittances are generally thought to have positive effects, for instance, they can contribute to poverty reduction in recipient countries (e.g., Adams, 2006; Acosta et al., 2006, respectively for Guatemala and Mexico); they can be spent on consumption, but also invested in education, health care and physical assets, alleviating liquidity constraints (e.g., Woodruff and Zenteno, 2007; Cox Edwards and Ureta, 2003; Adams, 2006). Nonetheless, their net effect is not so clear, being these positive effects counterbalanced by more ambiguous effects. For instance, their macroeconomic effects are not so clear. On the one hand, remittances are found to have a positive impact on economic growth in less financially developed countries by providing an alternative way to finance investment (e.g., Giuliano and Ruiz-Arranz, 2009) or by promoting financial development (e.g., Aggarwal et al., 2011). On the other hand, some studies find evidence that remittances lead to a phenomenon similar to the “Dutch disease”, i.e. implying an appreciation of the domestic currency with a subsequent loss in competitiveness and an adverse effect on economic growth (e.g. Acosta et al., 2009; Lartey et al., 2012). However, some studies found remittances to be countercyclical, such as after a natural disaster in the recipient country (e.g. Yang and Choi, 2007), alleviating the macroeconomic cost of the shock, and going in the opposite direction to the analogy with capital flows and the Dutch Disease, which assumes procyclicality.

Another debate concerns the distributional pattern of remittance receipts in migrants’ home country. Some studies find that remittances are distributed rather evenly among different income groups (e.g. Taylor and Wyatt, 1996), while other analyses identify that inequality is deepened with migration and remittances (e.g. Barham and Boucher, 1998). In addition, several authors show that the relationship between remittances and inequality exhibits a Kuznets curve. In particular, Stark et al. (1986) and McKenzie and Rapoport (2007) suggest that the network effect lowers migration costs over time and thus gradually facilitates migration from the low-income households. Hence, in the beginning when only the high-income households can afford migration costs, inequality is accentuated because remittances are received at the higher end of income distribution. This latter dispute calls for a dynamic analysis encompassing the short- and long-term effects of remittances on inequality.

Finally, another controversy relates to the question whether remittances come mainly from low-skilled or high-skilled migrants. In the literature, Ratha (2003) argued that educated migrants earn more and remit more, which suggests that the cost of the brain drain can be offset by migrants’ transfers. Using aggregate macro data, Faini (2007) and Nimii et al. (2008) found that remittances are negatively correlated with the average level of schooling of migrants, i.e. the high-skilled remits less. Micro-studies show the opposite. For example,
Kangasniemi et al. (2007) maintain that nearly half of Indian medical doctors working in the United Kingdom send remittances back to India and that these transfer on average represent 16 percent of the remitters’ income. Bollard et al. (2011), using cross-sectional micro-data from surveys of immigrants in eleven major destination countries, show a positive effect of education on the amount remitted. More recently, using macro bilateral data from 89 sending to 46 receiving countries over the period 1985-2005, Docquier et al. (2012) try to reconcile the literature showing that immigration policies determine the sign and magnitude of the relationship between remittances and migrants’ education: a more high-skilled pool of migrants will send more (resp. less) remittances if the destination country has a more restrictive (resp. selective) immigration policy.

Remittances - Results

In our analysis we focus on the debate over the relative propensity to remit between high and low-skilled migrants. Therefore we consider the recent evidence that the high-skilled may have lower propensity to remit (Faini, 2007; Nimii et al., 2008), and we conduct an alternative simulation assuming that the shock of additional high-skilled emigration does not add to the amount of remittance receipts. As shown in Figure 3.a, the total impacts in terms of GDP per capita are very much identical to the results with the usual calibration. In other words, in terms of domestic production in the developing regions, the impact of brain drain and its direct and indirect effects are hardly altered by remittance receipts. This is not a surprising outcome because, first, not all remittances are invested in productive activities; second, capital mobility implies that the remittance-funded investments do not necessarily take place in the South, but conform to international arbitrage; third the literature on remittances and growth is not clear cut: while some studies show that remittances promote growth (e.g. Aggarwal et al., 2011), others show that remittances could lead to a phenomenon similar to the "Dutch disease effect", with an appreciation of the domestic currency (e.g. Acosta et al., 2009; Larkey et al., 2012), and a subsequent possible negative effect on growth.

However, the additional remittance receipts, which have a dynamic effect to raise residents’ assets via saving, act to improve the welfare of those left behind. The importance of the role played by remittances can be noticed in Figure 3.b when we consider the GNI per capita economic indicator. It is observed that, in relation to the simulation with the usual calibration, all regions are adversely affected in the alternative scenario where the high-skilled have lower propensity to remit, although some suffer more and others less. Take the period 2060 for

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9 It should be noticed that in our simulations, we assume that remittances are distributed equally among all residents living in the same developing region.
10 In fact, the total impacts do become slightly more pessimistic when the additional high-skilled emigrants send back no remittances, but the differences in magnitudes are nearly undetectable.
11 See, for example, the survey in Massey et al. (1998) where remittances are documented to be spent largely on consumption in various studies.
example. MEN and SSA are the hardest hit regions because, looking at the data, they receive relatively large amounts of remittances with respect to their GDP. While MEN sees the positive impact on its GNI per capita dwindled from 0.56% to 0.40%, SSA has the total impact changed from -0.12% to -0.26%.

Finally, in this alternative scenario, inequality is worsened in each region. Again, in 2060, MEN is the hardest hit regions with the total impact changed from -1.35% to -1.21%, followed by RUS (with the total impact changed from -1.83% to -1.70%) and SSA (with the total impact changed from -1.15% to -1.03%).

**Remittances - State of the art**

To resume, in our simulations, we find that remittances from high-skilled have a negligible role in production, but play an important role in subsidizing the income of those left behind. When the high-skilled have a lower propensity to remit, all the regions are negatively affected in terms of GNI per capita. On the distributional side, this implies that income inequality is worsened too. Thus, as the impact of remittances from migrants abroad is non-negligible in improving the welfare of those left behind, it is important to shed lights on the debate on the distributional pattern of remittance receipts in migrants’ home country and, in particular, on remittance-patterns of high-skilled migrants.

At the moment, with the exception of Docquier et al. (2012), most of the studies on skill remittances pattern consider cross sectional data, both at the macro and micro level, being hard, among other things, to distinguish the effects of skill and of migration duration, as the high-skilled is more likely to stay permanently. New research considering panel data instead of cross-sectional data may be useful to better identify the remittance-patterns behavior. Moreover, most of remittances data used in the research only consider formal remittances sent to migrants’ origin countries. As in many countries informal remittances represent a large flow, it would be important to have data that give the possibility to take into account also informal remittances. This should be very important, as it is plausible to think that the propensity to use formal remittance channels could be positively correlated to the migrants’ education level.

**4.3 TFP Externality**

**TFP Externality - Literature**

The *TFP externality* refers to high-skilled diaspora abroad affecting technology diffusion. Despite the wide anecdotal evidence (e.g. Biao, 2006; Meyer and Brown, 1999; Meyer, 2001; Saxenian, 1999, 2001, 2002) which underlines that high-skilled migrants from abroad can foster productivity growth by promoting knowledge circulation, very few studies aim at investigating these issues. Most of these studies consider technology spill-over from the U.S. and identify
Figure 3: Lower propensity to remit

a. Effect on GDP per capita

b. Effect on GNI per capita

b. Effect on High-to-Low Skilled Inequality
the role of scientific diaspora networks by using patent citation data. For example, Kerr (2008) focus on patent-citation data in the U.S. community of researcher and finds that a larger ethnic research community in the U.S. improves technology diffusion to less advanced countries of the same ethnicity. Using patent citation data for Indian inventors, Agrawal et al. (2008) show that spatial and social proximity increase the probability of knowledge flows between individuals, even if the co-location effect is larger than the diaspora effect. In a related study, Agrawal et al. (2011) find that domestic access to knowledge facilitated by the diaspora is relatively more important for high-value inventions, but less important in the production of average inventions. Therefore, the effect of emigration on domestic innovation will depend on the relative value of the most important inventions compared to the others. More generally, Papageorgiou and Spilimbergo (2009) estimate the effect of foreign education on country-specific TFP growth rates and find that technology adoption is greatly facilitated by students trained abroad. In the same vein, Lodigiani (2008) considering the role of both high-skilled migration and human capital. She shows that former can induce technology transfers (technological imitation) in countries far from the frontier, while the latter is important for technology developments (technological innovation) in countries closer to the frontier.

**TFP Externality - Results**

Figure 4 shows an alternative simulation where we abstract from the TFP externality. The total impacts on GDP per capita are far more optimistic for some regions (EAS, LAC, SSA, CHI), more pessimistic for others (MEN, IND) and almost the same for RUS (see Figure 4.a). Recall that productivity (TFP) growth in our model is affected by increased high skilled emigration, as it modifies human capital and the size of high-skilled diaspora abroad (and therefore the capacity of a region to innovate or adopt). In particular, TFP growth increases in human capital (and decreases in high skilled emigration) when the economy is not too far from the frontier and it is likely to rely more on innovation. Moreover, TFP growth increases in high skilled emigration, when the economy is far from the frontier and it is likely to rely more on adoption. This explains the differences between regions. MEN, IND are regions far enough from the frontier to suffer from the lack of the technology adoption channel (for MEN the scale of positive impacts are decreased from 0.31% to 0.24% in 2060 and for IND from 0.57% to 0.26% in 2060). The opposite happens for EAS, LAC, CHI. For SSA the total impacts on GDP per capita are now more optimistic even if SSA is the farthest country from the frontier. Probably, human capital in SSA is so low that technology adoption is very

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12Data on TFP are constructed following Lodigiani (2008), who follows Vandenbussche et al. (2006). From our constructed TFP data, CHI’s distance to technological frontier is not low enough to benefit much from the diaspora externality on technology diffusion.
unlikely to happen through increased high-skilled diaspora.\textsuperscript{13} In the medium-to-long run, all the seven developing regions enjoy increased GDP per capita. Similar patterns are observed when considering the total impacts on GNI per capita (see Figure 4.b), while changes are negligible when considering impacts on high-to-low skilled income inequality (see Figure 4.c)

**TFP Externality - State of the art**

Our results show the non-negligible effect of the TFP externality in production. However, since the literature on migration and technology adoption is new and relatively not exhaustive, more research should be conducted along the productivity channel. This is especially required, given the shortcomings of existing studies. For instance, Lodigiani (2008) introduces in a neo-Schumpeterian framework diaspora externalities induced by high-skilled migration in the U.S.; in that context spill-over effects coming from non-leader, but more advanced economies are not taken into accounts. The study of Papageorgiou and Spilimbergo (2009) introduces, instead, weighted technology gaps in a bilateral setting, thus considering all the spill-over effects coming from any country that is more advanced. However Papageorgiou and Spilimbergo (2009) do not take into account the interplay effects of human capital and high-skilled emigration on TFP growth through innovation/imitation activities as instead Lodigiani (2008) does. This is important as resident high-skilled labor force is shown to be crucial. In particular, bilateral data on migration, that consider complete bilateral matrices of migration stocks, may be useful to further investigate this channel in order to consider all the possible spill-over effects coming from any migrants’ destination countries, given the level of resident human capital.\textsuperscript{14}

In addition to that, from our results it appears that when we abstract from the TFP externality, the total impacts on GDP per capita are far more optimistic for some regions closer enough to the frontier, and intuitively where innovation activities are relatively important. In our model, we assume that high-skilled migrants help the country to adopt, but not to innovate. It would be interesting to investigate whether high-skilled migrants can foster innovation as well: the knowledge acquired by emigrants abroad and transferred to their origin countries, could enhance the skills of the remaining workers there and facilitate the creation of new ideas, given an appropriate institutional context. At this purpose, Naghavi and Strozzi (2011) consider a panel of 35 low-income countries ranging from 1995 to 2006, and show that migration increases the number of resident patents in countries with strong intellectual property rights protection.

\textsuperscript{13}This is in line with the literature on absorption capacity which maintains that very poor regions can neither innovate nor adopt new technologies, because they lack of a minimum amount of human capital

\textsuperscript{14}A new and exhaustive bilateral database has been constructed by Ozden et al. (2011) in a panel setting, but migrants are not distinguished by educational attainment. Docquier et al. (2011) consider complete bilateral matrices of migration stocks by skill level for two year.
Figure 4: Lack of TFP externality

a. Effect on GDP per capita

b. Effect on GNI per capita

b. Effect on High-to-Low Skilled Inequality
4.4 FDI Externality

FDI Externality - Literature

The *FDI externality* originates from a less explored stream of the literature showing that highly skilled migrants may induce positive externalities by reducing transaction costs and favoring foreign direct investment.

Migrants, in fact, may create (or substitute for) trust in a weak international legal environment. They may provide enforcement of reputational sanctions to deter opportunism and violations of contracts. They may provide market information (relating to their origin country) that is difficult or costly to obtain. They may overcome many contractual, communication, and cultural barriers, thus favoring international transactions.

Example of empirical works trying to measure the magnitude of the diaspora externality in inducing investments, are Gao (2003) and Tong (2005) for studies on Chinese networks, or Buch et al. (2006) for Germany. This latter, for instance, use state-level German data to investigate whether and how migration and FDI are linked. This study shows that there is more inward FDI in German states that host a large foreign population from the same country of origin. This agglomeration effect is confined to higher-income source countries.

Considering the skill structure of migrants, the relationship between FDI and migration is shown to be driven by the presence of migrants with a post-secondary education (Kugler and Rapoport, 2007; Docquier and Lodigiani, 2010; Javorcik et al., 2011). In particular, using aggregate data, Docquier and Lodigiani (2010) find evidence of significant network externalities in a dynamic empirical model of FDI-funded capital accumulation.

Along the same lines, using bilateral US FDI outflows and US immigration data by country of origin and education level, Kugler and Rapoport (2007) also find strong evidence of a complementarity between US FDI and high-skilled migration.

Javorcik et al. (2011) also examine the relationship between the presence of migrants in the United States and US FDI in the migrants’ origin countries, but they explicitly take into account the endogeneity problem that has been ignored in Kugler and Rapoport (2007). Again, they find that FDI is positively correlated with the presence of migrants from the host country with a stronger relationship for migrants with tertiary education.

In addition to that, Kim and Park (2013) emphasize the role of foreign educated workers in attracting FDI from the countries where they acquired education.

Recently, Foley and Kerr (2013), using firm level-data from the Bureau of Economic Analysis, show that ethnic innovators employed at U.S. multinational firms have a positive impact on FDI, and on affiliate R&D activity in their native countries. This last study contributes to the literature pointing out the importance of the links between immigration, FDI and knowledge diffusion.
FDI Externality - Results

In our model the high-skilled diaspora externality may reduce the country information related risk premium that influences investment choices. As the shock increases the size of the high-skilled diaspora abroad, it reduces the premium and stimulates *ceteris paribus* foreign direct investment at origin for all the regions. With more FDI, capital inputs are increased and, consequently, total domestic production, thus contributing to positive effects on GDP per capita. Figure 5 presents the after-shock consequences under the alternative scenario *without FDI diaspora externalities*. Without FDI diaspora externalities, as shown in Figure 5.a, the predictions on GDP per capita are clearly more pessimistic than in the benchmark scenario. All the seven developing regions either experience a minor increase or a higher decrease in GDP per capita, but changes are modest, implying that diaspora effects on risk premium are not so relevant for all developing regions. Similar patterns are observed for GNI per capita (Figure 5.b). No changes are observed in this alternative scenario when considering high-to-low skilled income inequality, since the skilled-premium is not affected by the lack of FDI diaspora externalities (Figure 5.c).

FDI Externality - State of the art

The recent literature on FDI and migration unambiguously finds that immigrants keep interacting with their origin countries with a positive effect on FDI flows. If exchanges by themselves are a necessary element for a "brain gain" to exist, they are insufficient to conclude that this "brain gain" is effectively in place (Kerr, 2013). Our study shows that FDI externalities do not have a great impact on growth. This can be due to several reasons. First, it might be the case that a more disentangled effect should be considered in order to understand the relative importance of FDI externalities on migrants' native countries, for instance, considering the effect of the delocalization of innovative activities in migrants’ origin countries, and performing an analysis at sectoral level (in some sectors FDI externalities could be more relevant than in other sectors). The empirical paper of Foley and Kerr (2013), for instance, goes in that direction, linking immigration, FDI, innovation and knowledge diffusion. FDI in fact can be a key mechanism to transfer knowledge globally. Second, at macro and aggregate level, to better estimate the magnitude of this effect, it will be important to have a more complete analysis, that consider a complete bilateral setting, in a panel contest, in order to control for possible specific characteristics of the source and the destination countries that might affect bilateral investment flows.
Figure 5: Lack of FDI externality

a. Effect on GDP per capita

b. Effect on GNI per capita

b. Effect on High-to-Low Skilled Inequality
5 Concluding Remarks

Table 2: Snapshot of main results

<table>
<thead>
<tr>
<th>BD channel</th>
<th>GDP per capita</th>
<th></th>
<th>GNI per capita</th>
<th></th>
<th>Inequality</th>
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<tr>
<td></td>
<td></td>
<td>2050</td>
<td>2100</td>
<td>2050</td>
<td>2100</td>
</tr>
<tr>
<td>Total impact</td>
<td></td>
<td>- to +</td>
<td>0- to +</td>
<td>- to ++</td>
<td>0- to +</td>
</tr>
<tr>
<td>No Incentive effect</td>
<td></td>
<td>- - - to +</td>
<td>0- to ++</td>
<td>- - - to ++</td>
<td>0- to ++</td>
</tr>
<tr>
<td>Lower propensity</td>
<td></td>
<td>- to +</td>
<td>0- to ++</td>
<td>- to ++</td>
<td>0- to +</td>
</tr>
<tr>
<td>to remit</td>
<td></td>
<td>- - to +</td>
<td>0- to ++</td>
<td>- - to ++</td>
<td>0- to ++</td>
</tr>
<tr>
<td>No FDI externality</td>
<td></td>
<td>- to +</td>
<td>0- to ++</td>
<td>- to ++</td>
<td>0- to +</td>
</tr>
<tr>
<td>No TFP externality</td>
<td></td>
<td>- to +</td>
<td>0- to ++</td>
<td>- to ++</td>
<td>0- to +</td>
</tr>
</tbody>
</table>

Table 2 presents the effects on GDP per capita, GNI per capita and inequality of a 20 percent increase in the forecasted flow of high-skilled migrants from every developing region to each developed region. The symbols in the table refer to percent changes in each indicator (relative changes) in the following manner:

- ‘0-’ stands for 0% to -0.25%, ‘-’ for -0.25% to -0.5%, ‘- -’ for -0.5% to -1%, ‘- - -’ for more than -1%, ‘0+’ stands for 0% to 0.25%, ‘+’ for 0.25% to 0.5%, ‘++’ for 0.5% to 1%, ‘+++’ for more than 1%.

Note that the scale of the additional high-skilled emigration is small compared to the regional population since it implies a long-run reduction in the labor force that does not exceed 1%, except in LAC (1.28%) and EAS (2.19%).

The brain drain has long been a major source of concerns, especially with regard to South-North high-skilled migration. More recently, some studies highlights positive effects from high-skilled migration. By combining major results of existing theoretical and empirical literature in a general equilibrium framework of the world economy, we identify the forces which should be further investigated.

Table 2 summarizes the effects on GDP per capita, GNI per capita and high-to-low high-skilled income inequality.

Considering alternative simulations where we abstract from each channels by turns, we found that the short-run impact of brain drain on resident human capital is crucial and produces large impacts on economic production and income inequality.

Furthermore, when we abstract from the TFP externality, the total impacts on GDP per capita are far more optimistic for some regions and more pessimistic for others, according to the region’s relative distance to the technological frontier. Given that the literature on migration and technology adoption is new and relatively not exhaustive, more research should be conducted along the productivity channel.

Finally, FDI externality is found to have a limited impact on migrants’ sending countries, but further studies are required in order to have more reliable estimations. In addition, a more completed framework linking migration, FDI, and knowledge transmission is essential to understand the net effect of the diaspora on home countries.

Overall, it seems then high-skilled migrants can facilitate the global transfer of knowledge. From the literature, however, it is still not clear whether migrants help more a country to innovate or imitate, and in which sectors ad through which mechanisms they can have a more crucial role. Unfortunately, in our study we disregard the role of high-skilled migrants in
innovation activities.

Finally, as the impact of remittances from migrants abroad is non-negligible in improving the welfare of those left behind, it is important to shed lights on the debate on the distributional pattern of remittance receipts in migrants’ home country and, in particular, on remittance-patterns of high-skilled migrants.

To conclude, in order to better analyze several direct and feedback effects caused by high-skilled migration, and to assess the global impact of the brain drain on developing countries, much work remains to do. This is especially true regarding channels which are not well explored, and whose impact appears to be relevant, but requires additional studies in order to be considered as reliable. This study comments on four main brain drain channels. Of course the inclusion of other channels, such as return migration, or additional networks effects, may be helpful for further investigations.

References


Saxenian, A. (2001). Bangalore, the silicon valley of India? CREDPR.


Table 3: List of countries by region

<table>
<thead>
<tr>
<th>Region Code</th>
<th>Region Name</th>
<th>Country List</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAM</td>
<td>North America</td>
<td>United States and Canada.</td>
</tr>
<tr>
<td>ADV</td>
<td>Advanced Countries</td>
<td>Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.</td>
</tr>
<tr>
<td>JAP</td>
<td>Japan</td>
<td>Japan.</td>
</tr>
<tr>
<td>EAS</td>
<td>Eastern Europe</td>
<td>Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Poland, Romania, Serbia and Montenegro, Slovakia and Slovenia.</td>
</tr>
<tr>
<td>MEN</td>
<td>Middle East and North Africa</td>
<td>Algeria, Bahrain, Cyprus, Egypt, Iran (Islamic Republic of), Iraq, Israel, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Malta, Morocco, Occupied Palestinian Territory, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, Turkey, United Arab Emirates and Yemen.</td>
</tr>
<tr>
<td>LAC</td>
<td>Latin America and Caribbean</td>
<td>Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay and Venezuela.</td>
</tr>
<tr>
<td>RUS</td>
<td>Former Soviet Union</td>
<td>Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.</td>
</tr>
<tr>
<td>CHI</td>
<td>Chinese World</td>
<td>Brunei, Burma, Cambodia, China, East Timor, Hong Kong, Korea, Lao People’s Democratic Republic, Macau, Mongolia, Philippines, Singapore, Thailand and Vietnam.</td>
</tr>
<tr>
<td>IND</td>
<td>Indian World and Pacific Islands</td>
<td>Afghanistan, Bangladesh, Bhutan, Federated States of Micronesia, Fiji, India, Indonesia, Malaysia, Maldives, Nepal, Pakistan, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Tonga and Vanuatu.</td>
</tr>
</tbody>
</table>
Figure 6: Lack of incentive effects in 2060

a. GDP per capita

b. GNI per capita

c. High-to-Low Skilled Income Inequality
Figure 7: Lower propensity to remit in 2060

### a. GDP per capita

- Calibration
- Lower Propensity to Remit

### b. GNI per capita

- Calibration
- Lower Propensity to Remit

### c. High-to-Low Skilled Income Inequality

33
Figure 8: Lack of TFP externality in 2060

### a. GDP per capita

- Calibration
- Lack of TFP externality

### b. GNI per capita

- Calibration
- Lack of TFP externality

### c. High-to-Low Skilled Income Inequality

34
Figure 9: Lack of FDI externality in 2060

a. **GDP per capita**

b. **GNI per capita**

c. **High-to-Low Skilled Income Inequality**

35