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International Remittances and Brain Drain in Ghana

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Abstract. This paper presents a static computable general equilibrium (CGE) framework to numerically examine the impact of international remittances and the brain drain on poverty reduction as well as income inequality in Ghana. The generalized framework with the latest Ghanaian input-output table of year 2005 with 59 different production sectors provides the following results: On the impact of international remittances, more remittances reduce poverty, and expand the Ghanaian economy. On the impact on income inequality, it depends on who receives more remittances. If the rural (urban) households receive more remittances, then income inequality shrinks (widens). On the impact of the brain drain, it is negative to both poverty reduction and income inequality, even if the externality effect of the brain drain is taken into account. On the overall impact of both remittances and the brain drain in Ghana, income inequality becomes more severe. On the other hand, the overall impact on poverty reduction, it depends on the amount of remittances as well as the sector where the brain drain occurs. As long as the brain drain occurs in either the education or the health sector, then the positive impact of remittances outweighs the negative impact of the brain drain. However, if the brain drain occurs in all sectors, then the overall impact would result in the damage of Ghanaian economy. Even though the positive impact of international remittances is taken into account, the Ghanaian economy has been damaged by the brain drain, and emigration from Ghana has resulted in more income inequality and lower income.

Keywords. Ghana, Remittance, Brain Drain, Poverty, Income Inequality, Computable General Equilibrium (CGE) Model, Simulation.
JEL. C68, D58, I32, O15.

1. Introduction

This paper examines the impact of international remittances as well as the brain drain on poverty reduction and income inequality in Ghana within a static computable general equilibrium (CGE) framework with its latest Input-Output Table.

The increasing trend of international remittances in Ghana can be observed in accordance with the same pattern of the number of emigrants, and the positive relationship between international remittances and emigration seems mutual, as shown in Figure 1 and 2. The increasing trend of inflows of remittances has resulted in its relatively more importance and its growing impact on the whole

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Ghanaian economy. While the slowdown of the growth rate of the global flows of remittances is expected in year 2015 due to weak economic growth of Europe as well as deterioration of the Russian economy, the World Bank (2015) also forecasts that the global flows of remittances will again recover in year 2016 and 2017 in line with the expected global economic recovery[i]. The increasing trend of remittances and an expectation of global economic recovery both imply that remittances will play a more important role in Ghana.

The negative impact of emigration on the country of origin is recognized as the brain drain, particularly the impact of outflows of skilled labor on an economy of the country of origin. While increasing international remittances can be recognized as an injection to Ghana and thus they can be expected to stimulate the Ghanaian economy, the increasing number of emigration would reversely result in damaging the economy through its brain drain effect.

Djiofack et al. (2013) has recently found out in their simulations of a CGE model that the negative impact of the brain drain would outweigh the positive impact of remittances on income in Cameroon based on their parameter values estimated with the data of African countries, and they concluded that the overall impact of migration on poverty reduction is negative in Cameroon even though the positive impact of remittances is taken into account. They also pointed out that an increase in remittances would result in an expansion of income inequality in Cameroon since a larger ratio of remittances will be sent to relatively richer households, which live in the urban area. It is often observed particularly in developing countries that income inequality tends to become larger through the process of an economic expansion. Indeed income inequality has become wider in Ghana recently (Ghana Statistical Service (2014))[ii].

In the literature, while it has been argued that increased remittances help poverty reduction, the results of the impact of increased remittances on income inequality are mixed. Furthermore, the results of the impact of the brain drain on poverty reduction are also mixed in the macroeconomics literature. In the current literature, they argue that there is a positive externality effect of emigration, and the direct negative effect of the brain drain on poverty reduction might be cancelled out by the positive externality effect of emigration. Regarding the impact of the brain drain on income inequality, no clear conclusion has been obtained in the literature yet.

The expected global economic recovery and rapid globalization over the world economy would stimulate more outflows of skilled labor from Ghana as well as more international remittances to Ghana. Then, the purpose of this paper is to numerically measure the magnitude of the impact not only of international remittances but also of the brain drain on poverty reduction and income inequality in Ghana.

In order to specifically examine the impact of international remittances on income inequality, this paper explicitly considers several different inputs in production such as skilled labor, unskilled labor, capital for agriculture, general capital, and land. This paper also takes into account heterogeneity of households in the rural and urban areas. Since the latest Input-Output Table is used to specify parameter values in our CGE model, simulation results could be quite realistic. Indeed, the benchmark model can perfectly capture the actual Ghanaian economy within the model. Then the impact of international remittances on income inequality is explored. Furthermore, this paper explicitly considers how households use increased remittances. As Adams & Cuecuecha (2010; 2013) empirically pointed out recently, remittances would be used for particular goods; investment goods. The receipt of remittances can cause behavioral changes at the household level.

On the impact of the brain drain, this paper also considers the externality effect of emigration, which is often called the 'brain' effect. This positive externality effect has been argued within the endogenous growth theory that emigration has not only the negative 'brain drain' effect but also the positive 'brain' effect on the country of origin by stimulating more investments on education.

Our simulation results show as follows. On the impact of international remittances on poverty reduction, it is positive. if households use increased international remittances only for investment goods such as education, housing, and health, as Adams & Cuecuecha (2010; 2013) found, then the positive impact on poverty reduction is further stronger. The positive impact on poverty reduction is driven through the demand side, and more consumption generated by increased remittances stimulates production[iii]. This eventuates in more income of both rural and urban households. Income of the rural households increases even when only urban households receive additional remittances.

On the impact of international remittances on income inequality, it depends on who receives increased remittances. When the rural (urban) households enjoy more remittances, then income inequality becomes smaller (bigger). As Djiofack et al. (2013) suggested for the Cameroon case, this is the case for Ghana as well.

Regarding the impact of the brain drain on poverty reduction, the brain drain results in a decrease in GDP, and its impact is thus negative on poverty reduction. While the impact of the brain drain from the 'public administration' sector is negatively the largest, the negative impact of the brain drain from the 'health' sector on the Ghanaian economy is quite small. This is the same result as what Docquier & Rapoport (2012) pointed out for African countries.

On the impact of the brain drain on income inequality, the impact is also negative, and the brain drain generates more income inequality. However, the magnitude of the negative impact on income inequality is quite small.

Furthermore, if positive externality of emigration is taken into account, the negative impact of the brain drain on both poverty reduction and income inequality is weaken. However, our simulation results suggest that under a realistic assumption on the magnitude of externality the positive effect of externality is limited, and the overall impact of the brain drain is negative to both poverty reduction and income inequality.

On the overall impact of international remittances and the brain drain, income inequality becomes more severe by both effects, even if the externality effect of the brain drain is taken into account. Regarding the overall impact on poverty reduction, it depends on the amount of remittances and the sector where the brain drain occurs. As long as the brain drain occurs in either the education or the health sector, then the positive impact of remittances outweighs the negative impact of the brain drain, thus resulting in poverty reduction. However, if the brain drain occurs in all sectors, then the overall impact would result in the damage of Ghanaian economy. The negative impact of the brain drain would outweigh the positive impact of international remittances when the brain drain occurs in all sectors. Even though the positive impact of international remittances is taken into account, the Ghanaian economy has also been damaged by the brain drain, and emigration from Ghana has resulted in more income inequality and lower income.

The paper is organized as follows. The next section reviews the literature on remittances and the brain drain, and then Section 3 explains the data and benchmark model. Section 4 simulates several scenarios with results and evaluations. Section 5 concludes the paper.

2. The Literature

The impact of international remittances and migration on economic growth, poverty, and income inequality in the countries of origin has growingly received great attention in the literature. Rapoport et al. (2006) and Adams (2011) surveyed the literature, and they pointed out that the results are quite mixed while a number of research have been conducted.

On the impact of remittances on poverty reduction, however, it is rather more straightforward: Remittances seem to reduce poverty (Adams & Page, 2005; Acosta et al., 2008; Gupta et al., 2009; and Adams & Cuecuecha, 2013)[iv]. Gupta et al (2009) explored the impact of remittances on poverty reduction in Sub-Saharan African countries, and they found the positive effect of remittances on poverty reduction. Adams & Cuecuecha (2013) studied the impact of remittances on investment and poverty in Ghana based on 2005-6 Ghana Living Standard Survey (GLSS 5), and they concluded the positive impact on poverty reduction. Adams & Cuecuecha (2013) also found out that households in Ghana would spend more at the margin on three investment goods: education, housing, and health[v].

In terms of the impact of remittances on income inequality, results are really mixed (Lipton, 1980; Stark et al., 1988; Taylor 1992; Barham & Boucher, 1998). Taylor (1992) explicitly took into account the indirect and the long run effects to investigate the full impact of remittances on inequality, and they found an inverted U-shaped curve between remittances and inequality over time[vi].

The impact of migration of skilled workers from developing countries, which is the so-called brain drain, has also been explored in the literature. While there is no one-to-one relationship between international remittances and the brain drain, both should be obviously related to each other very closely. Docquier & Rapoport (2012) reviewed four decades of economic research on the brain drain particularly related to development issues, and they summarized the literature consisting of three waves over time. The current literature consists of several arguments within the endogenous growth framework that the brain drain would eventually generate the positive impact on economic growth through its positive externality. Beine et al. (2001) and Beine et al. (2008) introduced a positive effect (brain effect) of education on a source country caused by an uncertainty in the migration opportunity as well as the conventional negative effect (drain effect) into the endogenous growth model. Faini (2007) argued the relationship between remittances and the brain drain, and found out empirically that the brain drain was associated with a smaller propensity to remit[vii].

Regarding the research on Ghana and Africa in terms of international remittances and the brain drain, in addition to Gupta et al. (2009), and Adam & Cuecuecha (2013), Agbola (2013) and Djiofack et al. (2013) should be noted. Agbola (2013) empirically found out the positive impact of remittances on economic growth as well as the crowding out effect of the conventional government policy on the private activities in Ghana, and he argued that the government spending should be shifted onto more production-enhancing sectors such as education and health related sectors. Djiofack et al. (2013) constructed a computable general equilibrium (CGE) model [viii] for Cameroon with parameter values estimated with the African country data set, and presented several suggestive results for African countries. In particular, they concluded that the negative impact of the brain drain on productivity outweighs the positive impact of remittances on increased income in African countries, and thus outflows of skilled workers (brain drain) would ultimately reduce income in Africa. They also found out that the effect of remittances on poverty reduction is quite limited, and further that remittances would result in an expansion of income inequality due to the fact

that the amount of remittances sent by skilled workers abroad is much larger than that by unskilled workers and also that the larger amount of remittances by skilled workers will be sent to the urban area rather than the rural area. Since households living in the urban area are richer than those in the rural area, remittances would further widen the income gap between the urban and rural areas.

This paper tries to develop a computable general equilibrium (CGE) model to numerically measure the impact of international remittances and the brain drain on poverty reduction and income inequality for Ghana. While the literature above consists of studies basically with econometrics techniques, this paper employs a multisector general equilibrium model. While Djiofack et al. (2013) econometrically estimated parameter values for Cameroon with the African country data set, this paper uses the latest Input-Output table of Ghana with 59 private sectors for parameter specification, so that the benchmark model can perfectly re-produce the actual Ghanaian economy within our model. Any simulations cannot be convincing without a good-fitted benchmark model. Then this paper uses the well-fitted benchmark model to simulate several scenarios about international remittances and the brain drain in Ghana to explore the impact of remittances and the brain drain on poverty reduction and income inequality.

In addition to the difference in the method and the data for estimation of parameter values from Djiofack et al. (2013), this paper explicitly takes into account the following two key issues argued in the current literature on remittances and the brain drain: This paper explicitly considers how households use increased remittances. As Adams & Cuecuecha (2010; 2013) empirically pointed out recently, remittances would be used for particular goods; investment goods. The receipt of remittances can cause behavioral changes at the household level. Furthermore, on the impact of the brain drain, this paper also considers the positive externality effect of emigration, which is often called the brain effect. This positive externality effect has been argued within the endogenous growth theory that the brain drain has not only the negative but also the positive impact on the country of origin by stimulating more investments on education.

3. Numerical Analysis

In order to obtain numerical effects of international remittances, and the brain drain, this paper uses the latest input-output table of Ghana within a general equilibrium framework, in order to make our simulation analysis realistic. By using the actual input-output table of Ghana, the paper has successfully realized the real economy within the model. This paper employs the conventional static computable general equilibrium (CGE) model with the actual input-output table of Ghana of year 2005. Note that all parameter values in the model are calculated by using the actual data, so that the calculated values of endogenous variables obtained within the model also become quite realistic.

3.1. Data

The latest input-output table of Ghana of year 2005 with 59 different intermediate sectors has been used in order to construct the social accounting matrix (SAM)[ix].

The World Bank (2006) points out that the true size of international remittances flows through formal and informal channels may be much higher than the formal size by perhaps 50 % or more. The Bank of Ghana reported that the total size of private transfers in year 2005 was 1549.76 million US dollars, and also that more than 80 % of the amount of received remittances was sent privately and only 13 % was carried out through banks or money transfer agencies. In the latest input-output table of Ghana of year 2005, while there are items of official international

remittances to rural and urban households through banks and money transfer agencies, the values of these items are relatively too small compared to the reported value by the Bank of Ghana. Then private transfers from abroad are categorized in exports of sector 51 in the input-output table, and it is assumed in this paper that the amount of private transfers is also included in international remittances, in order to capture the true size of international remittances[x]. Table 1 shows the amount of international remittances obtained from the input-output table of Ghana of year 2005 after the modification of the treatment of exports of sector 51. As the table shows, the amount of international remittances to the urban households is much higher than that to the rural households, and the total income per capita in the urban area is also much higher than that in the rural area, as shown in Table 2. This implies, as Djiofack et al. (2013) pointed in the Cameroon case, that more international remittances would result in more income inequality, since more remittances would be sent to richer households which usually live in the urban area.

3.2. Benchmark Calibration[xi]

The general equilibrium model consists of 59 different production sectors, heterogenous households, and the government. Each of 59 production sectors uses self-employed, unskilled labor, skilled labor, land, agriculture specific capital, general capital, land, and intermediate production goods in its production in order to maximize its profits. Each production sector optimally determines how much it exports its own good, how much it imports goods for its production, and how much it sells its own good domestically.

Households are heterogenous, depending on the place where they live; the rural area household, and the urban area household. Each household maximizes its utility which is defined over 59 different goods produced by 59 different production sectors. Disposal income of rural and urban households consists of after tax labor and capital income, transfers from the government, and remittances. Remittances include internal (from Ghana) and international (from abroad) remittances, both of which are treated separately. The government imposes taxes and tariffs on and gives subsidies to 59 different production sectors. The government also imposes a labor income tax on the households in the rural and urban areas, and gives transfers to them. The total tax revenue is used for its expenditure. 59 different commodity markets and factor markets are all fully competitive, so that all prices are determined at the fully competitive level. 59 different production sectors and the heterogenous households take all prices, tax rates, and subsidy rates as given.

The benchmark case should reflect the real Ghanaian economy in order to make the subsequent simulation scenarios realistic. Thus, the benchmark model should carefully be calibrated until the calculated values of all endogenous variables within the model become close to the actual values. Table 3-1 to 3-3 show the calculated model values as well as the corresponding actual values in year 2005.

4. Simulation Analysis

4.1. The Impact of Remittances (Simulation I)

In order to capture the pure impact of international remittances on poverty reduction and income inequality, it is assumed that only the amount of remittances increases in the following simulations, and outflows of skilled labor, namely the brain drain, remains unchanged.

As Djiofack et al. (2013) pointed out, more remittances to households in the urban area would induce more income inequality, since households in the urban area are richer than those in the rural area. Thus, the impact of an increase in

remittances is separately examined in the following simulations, depending on whether remittances are sent to rural or urban households.

Furthermore, the treatment of increased remittances also matters. In the literature there is an argument on how households use remittances; for consumption of usual goods, or of particular goods. If the former case happens in Ghana, then increased remittances can be treated simply as an increase in disposal income. On the other hand, if the latter case is observed in Ghana, then increased remittances should be treated differently. As Adams & Cuecuecha (2010; 2013) empirically pointed out recently, remittances would be used for particular goods; investment goods. They found out in their research (2013) that remittances would be used particularly for education, housing, and health in Ghana. Thus, simulations are conducted based on two assumptions. In the first simulation (Simulation I-1), it is assumed that increased remittances are simply treated as an increase in disposal income. Then, another simulation (Simulation I-2) is conducted again by assuming that increased remittances are used only for more investments on education, housing, and health. Two different simulations of the impact of international remittances are thus as follows:

Simulation I-1: Increased international remittances are transferred to rural and urban households separately. The increased remittances are treated as an increase in disposal income, so that households use them for more consumption of all goods.

Simulation I-2: Increased international remittances are transferred to rural and urban households separately. The increased remittances are treated differently from disposal income, so that households use them for more consumption of only education, housing and health goods.

Table 4 shows the results. The impact on poverty reduction is measured by the equivalent variation and GDP. While the change in GDP indicates the impact on poverty reduction of the whole economy, the equivalent variation shows the magnitude of poverty reduction for the rural and urban households separately. The impact on income inequality is measured by Gini Coefficient in this paper.

On the impact on poverty reduction, as long as households treat increased remittances as an increase in disposal income, then the impact of remittances is relatively limited in comparison with the case that households use increased remittances only for investment goods such as education, housing, and health, which corresponds to what Adams & Cuecuecha (2013) found for Ghana. In such a case the impact of remittances on poverty reduction is much stronger. While more remittances always result in poverty reduction of the whole economy (higher GDP) irrespective of who receives them, the impact is larger when urban households receive them. The positive impact on poverty reduction is driven through the demand side in our simulations, as Agbola (2013) empirically found. More consumption generated by increased remittances stimulates production, and eventuates in more income. This demand side effect becomes stronger when urban households receive more remittances. Income of the rural households also increases even when only urban households receive additional remittances due to this demand side effect. For instance, Simulation I-2 shows that when remittances to urban households increase by 30% then not only income of the urban households but also that of the rural households increase by 0.4376 million US dollars and 0.3092 million US dollars, respectively.

On the impact on income inequality, it depends on who receives increased remittances. When the rural (urban) households enjoy more remittances, then income inequality becomes smaller (bigger). As Djiofack et al. (2013) suggested for the Cameroon case, this is the case for Ghana as well. While the direction of the impact is the same between Simulations I-1 and I-2, the magnitude is different.

While income inequality always shrinks when the rural households receive increased remittances, the positive impact on income equality is smaller when more remittances are used for consumption of only education, housing, and health (Simulation I-2). This is because the demand side effect becomes weaker when increased remittances are used for consumption of only investment goods, thus resulting in the smaller positive impact on income inequality.

On the other hand, when more remittances are used only for such consumption, the impact on income inequality negatively becomes the largest when increased remittances are transferred to the urban households. This is because the demand side effect of more consumption by the urban households does not spread over the whole economy when the urban households use increased remittances only for more investment goods, and then the impact of the demand side effect to the rural households is relatively weakened. The weakened positive effect on the rural households and more remittances to the urban households jointly result in the worst outcome on income inequality.

4.2. The Impact of the Brain Drain (Simulation II)

Recent studies argue that the brain drain has two contrary effects: The direct effect negatively works on productivity in the economy of origin. This negative effect is often called the 'drain effect', and it reduces productivity in the short-run. On the other hand, in association with such a negative effect in the short-run, it stimulates more investments on education in the country of origin in the long-run. Individuals invest more on education since they expect to obtain more opportunities to emigrate their home country if they are more educated. However, if some of them cannot leave their home country against their expectation, then they could contribute to the improvement in productivity in their home country. This positive effect is often called 'brain effect', and this positive effect of externality results in higher economic growth in the long-run.

Since these two effects work in the opposite directions on the country of origin, two separate simulations are conducted in this paper. Firstly, it is assumed that skilled labor leaves Ghana without any positive externality. This case is examined in Simulation II-1. In Simulation II-1, only the 'drain effect' of emigration is taken into account. Then, in Simulation II-2 the impact of positive externality is taken into account when skilled labor leaves Ghana. In this simulation, the 'brain effect' is also considered. In Simulation II-2, it is assumed that happens in the following way: When skilled labor leaves a production sector in Ghana, then unskilled labor in the same sector can fully replace the skilled labor who left the country. This implies that the marginal productivity of unskilled labor increases up to that of skilled labor. For instance, this assumption implies that if a 30% of skilled labor leaves a sector then exactly a 30% of unskilled labor in the same sector becomes skilled. Then, a 70% of unskilled labor still remains unskilled in the sector. Since it is assumed that all prices are determined in corresponding fully competitive markets, newly skilled labor receives higher labor income. This assumption is called 'perfect' externality in this paper, and it seems unrealistic. In reality, even though positive externality is observed, the actual situation could be between Simulation II-1 and Simulation II-2. However, since it seems quite difficult to determine to the extent how much positive externality exists in actual Ghana, it is simply assumed that perfect externality exists in Simulation II-2, in order to be compared with Simulation II-1.

Table 5 shows top ten sectors which most pay labor income to skilled labor in Ghana based on the Input-Output Table of year 2005. The impact of outflows of medical doctors from Ghana on the Ghanaian economy is one of the most important issues in Ghana. Thus, in the following simulations, the impact of the

brain drain from 'public administration (sector 57)', 'education (sector 58)', and 'health (sector 59)' is examined. Then the following two simulations are explored:

Simulation II-1: The brain drain either from 'public administration (sector 57)', 'education (sector 58)', 'health (sector 59)', or all 59 sectors occurs. However, there exists no externality. Only the 'drain effect' is take into account.

Simulation II-2: The brain drain either from 'public administration (sector 57)', 'education (sector 58)', 'health (sector 59)', or all 59 sectors occurs. Furthermore, there exists perfect externality. Not only the 'drain effect' but also 'brain effect' are taken into account.

Table 6 shows the results. When there is no positive externality (with no 'brain effect'), GDP decreases, and the impact on poverty reduction is negative. Welfare of both rural and urban households decreases. In accordance with their relative sizes of income, the negative impact of the brain drain from the 'public administration' sector on GDP is most severe. On the other hand, the negative impact of the brain drain from the 'health' sector on the Ghanaian economy is limited. The negative impact of outflows of medical doctors from Ghana has been argued in Ghana. However, as long as its impact on the Ghanaian economy is concerned, the magnitude of the impact is not so large,[xii]as Docquier & Rapoport (2012) pointed out for African countries.

Regarding the impact on income inequality, it is also negative, while the magnitude is much smaller than the case of remittances. The Ghanaian economy is damaged by the 'drain effect', and income of both rural and urban households decreases. Table 6 shows that income of the rural households decreases more than that of the urban households by the direct 'drain effect'.

On the other hand, when perfect externality, namely the 'brain effect', is also taken into account, the above negative impact of the brain drain is weakened, as the result of Simulation II-2 shows in Table 6. Due to the strong assumption of the perfect externality effect, the brain drain eventually reduces poverty slightly, and it also results in the slight improvement in income inequality.

However, such results have been obtained based on the strong assumption of perfect externality. Since the positive impact on poverty reduction as well as income inequality is quite limited even under the strong assumption of perfect externality (Simulation II-2). In reality, even if some externality exists, the actual Ghanaian economy would be the case between Simulation II-1 and Simulation II-2. Thus, the actual Ghanaian economy is likely to have suffered from the brain drain even though externality is considered.

4.3. The Overall Impact of Remittances and the Brain Drain

This section tries to combine the results obtained in the above two sections in order to numerically measure the overall impact of international remittances and the brain drain on poverty reduction as well as income inequality. Djiofack et al. (2013) found out that the negative impact of the brain drain would outweigh the positive impact of remittances on the Cameroon economy. While more brain drain is associated with more remittances, Faini (2007) and Adams (2009) pointed out that more skilled workers tend to remit less.

Before showing the numerical results of the overall impact, Table 7 shows the qualitative results of the above simulations. Table 7 indicates that as long as the urban households receive international remittances then the overall impact on income inequality seems negative. On the other hand, when the urban households receive remittances, then the overall impact on poverty reduction depends on the relative magnitude of the positive impact and the negative impact of the brain drain. Table 8 shows the numerical results of the overall impact[xiii]. As Table 7 suggests, when the urban households receive more remittances, then income inequality indeed becomes worse, even though perfect externality is assumed.

Since it is not realistic to assume that only rural households receive international remittances, this numerical result shows that the overall impact of international remittances and the brain drain has induced more income inequality in Ghana. Emigration from Ghana has resulted in more income inequality. On the impact on poverty reduction, the overall impact depends on where the brain drain occurs. If the brain drain occurs either from the education sector or the health sector, then the positive impact of international remittances would outweigh the negative impact of the brain drain, thus resulting in poverty reduction. This is the opposite result to Djiofack et al. (2013) for the Cameroon case. However, if the brain drain occurs only in the public administration sector, the result depends on how much the urban households receive international remittances as well as how much the positive externality effect of the brain drain is strong. Furthermore, it would be more realistic to assume that the brain drain occurs not only in the public administration sector but also in other sectors. The last several columns show this case, where the brain drain occurs in all 59 sectors. The overall impact of international remittances and the brain drain tends to be negative when the brain drain occurs in all sectors, even though some positive externality is taken into account. The comparison between the no externality and the perfect externality cases indicates that even if more than half positive externality is taken into account GDP would be reduced by the overall impact of international remittances and the brain drain. This implies that emigration from Ghana has also induced the damage of the Ghanaian economy even if the positive impact of international remittances is considered.

5. Concluding Remarks

This paper has presented a computable general equilibrium (CGE) framework to numerically examine the impact of remittances and the brain drain on poverty reduction, welfare, and income inequality in Ghana. This paper has used the latest Input-Output table of Ghana of year 2005 with 59 different production sectors to reproduce the actual Ghanaian economy within the model.

The results obtained in this paper are as follows: On the impact of international remittances on poverty reduction, it is positive. if households use increased international remittances only for investment goods such as education, housing, and health, as Adams & Cuecuecha (2010; 2013) found, then the positive impact on poverty reduction is further stronger. The positive impact on poverty reduction is driven through the demand side, and more consumption generated by increased remittances stimulates production. This eventuates in more income of both rural and urban households. Income of the rural households increases even when only urban households receive additional remittances.

On the impact of international remittances on income inequality, it depends on who receives increased remittances. When the rural (urban) households enjoy more remittances, then income inequality becomes smaller (bigger). As Djiofack et al. (2013) suggested for the Cameroon case, this is the case for Ghana as well.

Regarding the impact of the brain drain on poverty reduction, the brain drain results in a decrease in GDP, and its impact is thus negative on poverty reduction. While the impact of the brain drain from the 'public administration' sector is negatively the largest, the negative impact of the brain drain from the 'health' sector on the Ghanaian economy is quite small. This is the same result as what Docquier & Rapoport (2012) pointed out for African countries.

On the impact of the brain drain on income inequality, the impact is also negative, and the brain drain generates more income inequality. However, the magnitude of the negative impact on income inequality is quite small.

Furthermore, if positive externality of emigration is taken into account, the negative impact of the brain drain on both poverty reduction and income inequality is weaken. However, our simulation results suggest that under a realistic assumption on the magnitude of externality the positive effect of externality is limited, and the overall impact of the brain drain is negative to both poverty reduction and income inequality.

On the overall impact of international remittances and the brain drain, income inequality becomes more severe by both effects, even if the externality effect of the brain drain is taken into account. Regarding the overall impact on poverty reduction, it depends on the amount of remittances and the sector where the brain drain occurs. As long as the brain drain occurs in either the education or the health sector, then the positive impact of remittances outweighs the negative impact of the brain drain, thus resulting in poverty reduction. However, if the brain drain occurs in all sectors, then the overall impact would result in the damage of Ghanaian economy. The negative impact of the brain drain would outweigh the positive impact of international remittances when the brain drain occurs in all sectors. Even though the positive impact of international remittances is taken into account, the Ghanaian economy has also been damaged by the brain drain, and emigration from Ghana has resulted in more income inequality and lower income.

While this paper has used the Ghanaian input-output table, it would be notable to mention that it is applicable to all other countries in Africa in order to investigate the effect of remittances and the brain drain. Furthermore, the model can easily be generalized by incorporating policy instruments to examine the impact of policy changes such as tax reforms.

Finally drawbacks of this paper should be mentioned: The model is static, and it seems difficult to fully investigate the impact over time. As argued in the literature, the overall impact of remittances lasts over time. This implies that the framework is expected to be dynamic. It has also been assumed that labor supply is completely inelastic and immobile among different production sectors. This implies that the framework cannot capture the impact of the brain drain from a particular sector. If the brain drain is severe in a particular sector, then skilled labor would move over different sectors in reality.

However, by using the latest Input-Output Table of Ghana, this paper has developed a well-fitted benchmark model within a CGE framework, and it has numerically argued the impact of international remittances and the brain drain on poverty reduction and income inequality within a theoretical framework. It has also taken into account two key issues in the literature; behavioral changes towards remittances and externality of the brain drain. Since the benchmark model has successfully reproduced the real Ghanaian economy within the model, the numerical results also seem realistic.

Appendix : Tables and Figures

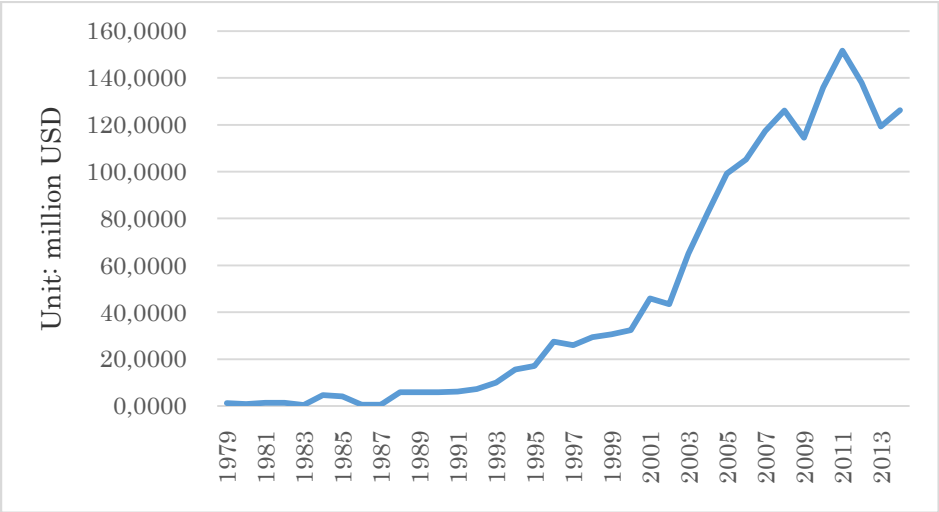

Figure 1. *International Remittances*
Data Source: World Bank

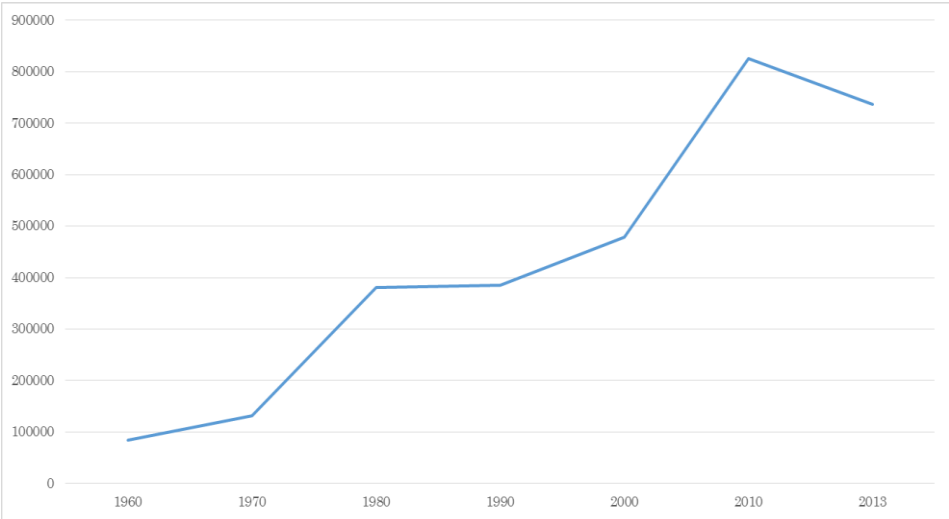

Figure 2. *The Number of Emigrants from Ghana*
Data Source: World Bank

Table 1. *International Remittances in year 2005 based on the IO Table year 2005*

Unit: million USD

		Formal	Informal	Total
To	Rural houeholds	45.11181696	168.34958	213.46139
	Urban households	175.726162	655.77995	831.50611
	total	220.8379789	824.12952	1044.9675
		Per a million population		
To	Rural houeholds	3.268972244	12.199245	15.468217
	Urban households	20.91978119	78.069041	98.988822
	total	24.18875343	90.268286	114.45704

Source: Input-Output Table of Year 2005
The amout of informal remittances is obtained based on the assumption that the amount of exports in sector 51 is treated as informal international remittances

Table 2. *Income and Population in year 2005*

Income: in million USD, and Population in million

	Population	Income
Rural houeholds	13.8	5054.3708
Urban households	8.4	5850.3813
total	22.2	10904.752
	Per a million population	
Rural houeholds		366.25876
Urban households		423.94068
total		790.19943

Source: Input-Output Table Year 2005 and GLSS 5

Table 3.1. *Final Consumption Goods by the Rural Household in the Benchmark Model*, $P_i^Q Q_i;\ i = 1,2,\cdots,59$

Unit: a million USD

i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
model	161.3466	1810.993	164.7513	3.5397	243.5304	246.1961	49.3526	23.5462	0.7045	29.1376	51.7212	0.0000	23.7231	0.0000	350.0597	0.0000	139.3511	0.0000	13.4950	0.0000
actual	161.3466	1810.993	164.7513	3.5397	243.5304	246.1961	49.3526	23.5462	0.7045	29.1376	51.7212	0.0000	23.7231	0.0000	350.0597	0.0000	139.3511	0.0000	13.4950	0.0000

i	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
model	46.5567	33.4926	38.3056	20.9585	58.7158	0.0000	137.0186	0.0000	326.8628	151.7803	11.3400	28.4616	253.5878	79.4779	207.1868	69.3121	35.5209	9.1542	0.0000	26.1875
actual	46.5567	33.4926	38.3056	20.9585	58.7158	0.0000	137.0186	0.0000	326.8628	151.7803	11.3400	28.4616	253.5878	79.4779	207.1868	69.3121	35.5209	9.1542	0.0000	26.1875

i	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
model	9.2716	143.8824	31.3530	244.9696	32.1250	316.4404	0.0000	0.4894	122.9051	0.0000	235.0137	67.2638	36.1436	19.8688	75.2528	91.3408	0.7734	2.1138	15.7557
actual	9.2716	143.8824	31.3530	244.9696	32.1250	316.4404	0.0000	0.4894	122.9051	0.0000	235.0137	67.2638	36.1436	19.8688	75.2528	91.3408	0.7734	2.1138	15.7557

Table 3.2. *Final Consumption Goods by the Urban Household in the Benchmark Model*, $P_i^Q Q_i$; $i = 1,2,\cdots,59$ (Unit: a million USD)

i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
model	54.8043	198.6549	13.7817	4.3154	118.0666	220.2583	31.0591	16.3610	0.0097	13.7614	18.1908	0.0000	46.1061	0.0000	223.3785	0.0000	86.8935	0.0000	2.8668	0.0000
actual	54.8043	198.6549	13.7817	4.3154	118.0666	220.2583	31.0591	16.3610	0.0097	13.7614	18.1908	0.0000	46.1061	0.0000	223.3785	0.0000	86.8935	0.0000	2.8668	0.0000

i	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
model	58.8608	58.6503	69.4302	35.9050	41.3304	0.0000	128.9009	0.0000	417.2806	173.8144	15.1842	67.3249	175.3232	92.1036	242.9253	82.6421	79.8833	23.6569	0.0000	95.4730
actual	58.8608	58.6503	69.4302	35.9050	41.3304	0.0000	128.9009	0.0000	417.2806	173.8144	15.1842	67.3249	175.3232	92.1036	242.9253	82.6421	79.8833	23.6569	0.0000	95.4730

i	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
model	24.1693	55.6489	1.3699	250.3509	30.5753	550.0410	0.0000	0.9181	255.0649	0.0000	776.6547	140.6510	114.0056	51.7732	177.2926	167.4242	2.2056	3.6677	14.7460
actual	24.1693	55.6489	1.3699	250.3509	30.5753	550.0410	0.0000	0.9181	255.0649	0.0000	776.6547	140.6510	114.0056	51.7732	177.2926	167.4242	2.2056	3.6677	14.7460

Table 3.3. *Economic Values of the Benchmark Model*
Unit: a million USD (except for Gini Coefficient)

	model	actual
Income		
Rural households	5054.370819	5054.370819
Urban households	5850.381344	5850.381344
Savings		
Private Sector		
Rural households	231.8894	231.8894
Urban households	138.6556	138.6556
Government Sector	745.4039	745.4039
Foreign Sector	1,986.8083	1,986.8084
GDP	11,429.3131	11,429.3131
Gini Coefficient	39.4	39.4

Table 4. *The Impact of International Remittances*
Unit: a million USD (except for Gini Coefficient)

Unit: a million USD except Gini Coeffficient	benchmark	increase in remittances to the RURAL household only			increase in remittances to the URBAN household only		
		10% increase	20% increase	30% increase	10% increase	20% increase	30% increase
		Simulation I - 1 (More remittances are treated as an increase in disposal income)					
Welfare (Equivalent Variation)							
rural household	0.0000	0.0320	0.0653	0.0996	0.0087	0.0214	0.0341
urban household	0.0000	-0.0053	-0.0105	-0.0153	0.0794	0.1587	0.2366
GDP	11429.3131	11429.0421	11428.8074	11429.8454	11431.8223	11437.6802	11443.7534
Gini Coefficient	39.40	37.94	36.41	34.86	42.48	45.40	48.27
		% increase from the benchmark value					
GDP		-0.0024%	-0.0044%	0.0047%	0.0220%	0.0732%	0.1263%
Gini Coefficient		-3.7142%	-7.5958%	-11.5105%	7.8284%	15.2374%	22.5152%
		Simulation I - 2 (More remittances are used for more consumption of only investment goods)					
Welfare (Equivalent Variation)							
rural household	0.0000	0.0479	0.1007	0.1497	0.0968	0.2050	0.3092
urban household	0.0000	0.0189	0.0439	0.0686	0.1625	0.3084	0.4376
GDP	11429.3131	11461.8917	11507.2452	11553.1977	11594.1791	11781.1238	11968.3522
Gini Coefficient	39.40	38.31	37.06	35.82	43.45	47.10	50.58
		% increase from the benchmark value					
GDP		0.2850%	0.6819%	1.0839%	1.4425%	3.0781%	4.7163%
Gini Coefficient		-2.7760%	-5.9338%	-9.0825%	10.2910%	19.5457%	28.3720%

Table 5. *Labor Income of Skilled Worker in Top 10 Sectors (Unit a million USD)*

Rank	1	2	3	4	5	6	7	8	9	10
Sector No.	57	58	47	27	59	54	56	49	28	53
Name	Public administration	Education	Construction	Fishing	Health	Business services	Community services	Electricity	Mining	Communication
Amount	377.379533	180.6853936	87.65120828	69.77185017	49.07618621	48.10106664	45.17145256	36.21301909	30.81719029	21.84097033

Table 6. *The Impact of the Brain Drain*
Unit a million USD (except for Gini Coefficient)

Unit: a million USD except Gini Coefficient	benchmark	increase in the Brain Drain from the Public Administration Sector (Sector 57) only			increase in the Brain Drain from the Education Sector (Sector 58) only			increase in the Brain Drain from the Health Sector (Sector 59) only			increase in the Brain Drain from All 59 Sectors		
		3% Increase	5% increase	10% increase	3% Increase	5% increase	10% increase	3% Increase	5% increase	10% increase	3% Increase	5% increase	10% increase
							Simulation II - 1 (with No Externality)						
Welfare (Equivalent Variation)													
rural household	0.0000	-0.0524	-0.0884	-0.1727	-0.0186	-0.0319	-0.0602	-0.0056	-0.0098	-0.0200	-0.1623	-0.2701	-0.5263
urban household	0.0000	-0.0462	-0.0769	-0.1498	-0.0185	-0.0307	-0.0574	-0.0054	-0.0091	-0.0180	-0.1397	-0.2309	-0.4490
GDP	11429.3131	11255.4284	11143.1025	10888.6990	11365.7017	11325.0675	11241.4757	11417.4880	11408.4567	11388.1787	10959.0031	10666.1859	10015.0625
Gini Coefficient	39.40	39.69	39.92	40.38	39.42	39.46	39.51	39.38	39.37	39.36	40.27	40.89	42.28
		% increase from the benchmark value			% increase from the benchmark value			% increase from the benchmark value			% increase from the benchmark value		
GDP		-1.5214%	-2.5042%	-4.7301%	-0.5566%	-0.9121%	-1.6435%	-0.1035%	-0.1825%	-0.3599%	-4.1149%	-6.6769%	-12.3739%
Gini Coefficient		0.7317%	1.3109%	2.4881%	0.0469%	0.1520%	0.2831%	-0.0623%	-0.0758%	-0.1122%	2.2116%	3.7931%	7.3209%
							Simulation II - 2 (with Perfect Externality)						
Welfare (Equivalent Variation)													
rural household	0.0000	0.0029	0.0051	0.0106	0.0010	0.0020	0.0045	-0.0009	-0.0011	-0.0016	0.0064	0.0112	0.0238
urban household	0.0000	-0.0027	-0.0042	-0.0081	-0.0017	-0.0025	-0.0045	-0.0013	-0.0018	-0.0031	-0.0086	-0.0141	-0.0272
GDP	11429.3131	11441.8318	11449.3233	11468.5256	11435.8913	11439.5220	11448.5500	11432.0430	11433.0353	11435.4568	11430.6845	11431.1365	11431.4839
Gini Coefficient	39.40	39.18	39.03	38.65	39.29	39.22	39.05	39.37	39.35	39.30	38.77	38.35	37.27
		% increase from the benchmark value			% increase from the benchmark value			% increase from the benchmark value			% increase from the benchmark value		
GDP		0.1095%	0.1751%	0.3431%	0.0576%	0.0893%	0.1683%	0.0239%	0.0326%	0.0538%	0.0120%	0.0160%	0.0190%
Gini Coefficient		-0.5634%	-0.9406%	-1.9115%	-0.2697%	-0.4496%	-0.8999%	-0.0733%	-0.1221%	-0.2442%	-1.5877%	-2.6730%	-5.4097%

Table 7. *The Qualitative Impact on Poverty Reduction and Income Inequality*

		Poverty Reduction	Income Inequality
International Remittances to:	Rural Household	positive	positive
	Urban Household	very positive	negative
Brain Drain with:	No Externality	negative	negative
	Perfect Externality	slightly positive	slightly positive

Table 8. *The Overall Impact of International Remittances and the Brain Drain*

			increase in the Brain Drain from the Public Administration Sector (Sector 57) only			increase in the Brain Drain from the Education Sector (Sector 58) only			increase in the Brain Drain from the Health Sector (Sector 59) only			increase in the Brain Drain from All 59 Sectors		
			3% Increase	5% increase	10% increase	3% Increase	5% increase	10% increase	3% Increase	5% increase	10% increase	3% Increase	5% increase	10% increase
No Externality Case (Only 'Drain Effect', but No 'Brain Effect')														
GDP (% change from the benchmark level)	increase in remittances only to the URBAN household by	30%	3.19%	2.21%	-0.01%	4.16%	3.80%	3.07%	4.61%	4.53%	4.36%	0.60%	-1.96%	-7.66%
		20%	1.56%	0.57%	-1.65%	2.52%	2.17%	1.43%	2.97%	2.90%	2.72%	-1.04%	-3.60%	-9.30%
		10%	-0.08%	-1.06%	-3.29%	0.89%	0.53%	-0.20%	1.34%	1.26%	1.08%	-2.67%	-5.23%	-10.93%
	increase in remittances only to the RURAL household by	30%	-0.44%	-1.42%	-3.65%	0.53%	0.17%	-0.56%	0.98%	0.90%	0.72%	-3.03%	-5.59%	-11.29%
		20%	-0.84%	-1.82%	-4.05%	0.13%	-0.23%	-0.96%	0.58%	0.50%	0.32%	-3.43%	-6.00%	-11.69%
		10%	-1.24%	-2.22%	-4.45%	-0.27%	-0.63%	-1.36%	0.18%	0.10%	-0.07%	-3.83%	-6.39%	-12.09%
Gini Coefficient (benchmark level is 39.40)	increase in remittances only to the URBAN household by	30%	50.87	51.10	51.56	50.60	50.64	50.69	50.55	50.55	50.53	51.45	52.07	53.46
		20%	47.39	47.62	48.08	47.12	47.16	47.21	47.08	47.07	47.06	47.97	48.60	49.99
		10%	43.74	43.97	44.43	43.47	43.51	43.57	43.43	43.42	43.41	44.33	44.95	46.34
	increase in remittances only to the RURAL household by	30%	36.11	36.34	36.80	35.84	35.88	35.93	35.80	35.79	35.78	36.69	37.32	38.71
		20%	37.35	37.58	38.04	37.08	37.12	37.17	37.04	37.03	37.02	37.93	38.56	39.95
		10%	38.59	38.82	39.29	38.32	38.37	38.42	38.28	38.28	38.26	39.18	39.80	41.19
Perfect Externality Case (with 'Drain Effect', and 'Brain Effect')														
GDP (% change from the benchmark level)	increase in remittances only to the URBAN household by	30%	4.83%	4.89%	5.06%	4.77%	4.81%	4.88%	4.74%	4.75%	4.77%	4.73%	4.73%	4.74%
		20%	3.19%	3.25%	3.42%	3.14%	3.17%	3.25%	3.10%	3.11%	3.13%	3.09%	3.09%	3.10%
		10%	1.55%	1.62%	1.79%	1.50%	1.53%	1.61%	1.47%	1.48%	1.50%	1.45%	1.46%	1.46%
	increase in remittances only to the RURAL household by	30%	1.19%	1.26%	1.43%	1.14%	1.17%	1.25%	1.11%	1.12%	1.14%	1.10%	1.10%	1.10%
		20%	0.79%	0.86%	1.02%	0.74%	0.77%	0.85%	0.71%	0.71%	0.74%	0.69%	0.70%	0.70%
		10%	0.39%	0.46%	0.63%	0.34%	0.37%	0.45%	0.31%	0.32%	0.34%	0.30%	0.30%	0.30%
Gini Coefficient (benchmark level is 39.40)	increase in remittances only to the URBAN household by	30%	50.36	50.21	49.83	50.47	50.40	50.22	50.55	50.53	50.48	49.95	49.53	48.45
		20%	46.88	46.73	46.35	46.99	46.92	46.75	47.07	47.05	47.00	46.48	46.05	44.97
		10%	43.23	43.08	42.70	43.35	43.28	43.10	43.43	43.41	43.36	42.83	42.40	41.32
	increase in remittances only to the RURAL household by	30%	35.60	35.45	35.07	35.72	35.64	35.47	35.79	35.77	35.73	35.20	34.77	33.69
		20%	36.84	36.69	36.31	36.96	36.88	36.71	37.03	37.01	36.97	36.44	36.01	34.93
		10%	38.08	37.94	37.55	38.20	38.13	37.95	38.28	38.26	38.21	37.68	37.25	36.17

Appendix: Model

The computable general equilibrium model of this paper employs the conventional static model. The Ghanaian economy is assumed to consist of 59 different production sectors, two different types of households, the government, and the investment firm sector. All 59 industries are allowed to have intermediate production processes, and they are assumed to maximize their profit. Each production sector employs 6 factors in its production; self-employed labor Ls, unskilled employed labor $Lusk$, skilled employed labor Lsk, capital specific for agriculture Ka, general capital Kn, and land La. Households are divided into two groups based on their living place indexed by h; the household living in the rural area $h = a$ and the household living in the urban area $h = b$. While households in different areas are different, households living in the same area are assumed to be identical. The household is assumed to maximize its utility over 59 different consumption goods.

The government is assumed to determine its tax revenue, its imports, its exports, income transfers to households, and its consumption in order to satisfy its budget constraint. The economy is assumed to be fully competitive, so that all prices are determined in the relevant markets in order to equate the amount of demand to the amount of supply at its fully competitive price level in equilibrium. Note that the model is static and thus the short-run effect is only investigated. Thus, it is assumed for simplicity that factor inputs are not mobile among different sectors in the short-run. All parameter values are presented in Table 6.

<Household>

Utility of the household indexed by h based on his/her living area is given by:

$$U^h = U^h(X_1^h, X_2^h, \ldots, X_{59}^h) = \sum_{i=1}^{59} \alpha_i^h \log(X_i^h), \quad h = a, b, \tag{1}$$

where X_i^h denotes consumption of good i consumed by type h. $\sum_{i=1}^{59} \alpha_i^h = 1$ is assumed for both types of h ($= a$ and b).

The household of type h is assumed to maximize (1) with respect to its consumption goods subject to its budget constraint such that:

$$\sum_{i=1}^{59} p_i X_i^h = B^h + I^h - S_p^h; \quad h = a, b$$

where p_i and I^h denote the price of good i and disposal income of type h, respectively. S_p^h denotes the total amount of savings, and the household is assumed to save the constant amount relative to its disposal income such that:

$$S_p^h = s_p^h I^h; \quad h = a, b$$

where the constant ratio, s_p^h, or the private saving rate, is given exogenously[xiv]. The value of s_p^h has been calculated by using the actual SAM. Then disposal income is given by

$$I^h = GTrans^h + Trans^h + Rm^h + \sum_{j=1}^{59} \left\{ \begin{array}{l} w_j^a \overline{Ka}_j^h + w_j^n \overline{Kn}_j^h + w_j^s \overline{Ls}_j^h \\ + w_j^{us} \overline{Lusk}_j^h + w_j^{sk} \overline{Lsk}_j^h + P_j \overline{La}_j^h \end{array} \right\}, \quad h = a, b$$

where $GTrans^h$, $Trans^h$, and Rm^h denote the government income transfers, net income transfers from the other type of the household, and the remittance sent from the rest of the world,

respectively[xv]. r_j^a, and r_j^n, denote the rental cost of capital specific for agriculture (Ka), and general capital (Kn) in sector j $(1, 2, \ldots, 59)$, respectively. w_j^s, w_j^{us} and w_j^{sk} denote the wage rate of self-employed labor (Ls), unskilled employed labor $(Lusk)$, and skilled employed labor (Lsk) employed in sector j $(1, 2, \ldots, 59)$, respectively. LP_j denotes the unit price of land (La). Each type is assumed to have endowments of $\overline{Ka}_j^h, \overline{Kn}_j^h, \overline{Ls}_j^h, \overline{Lusk}_j^h, \overline{Lsk}_j^h$, and $\overline{La}_j^h$ in sector j $(1, 2, \ldots, 59)$. Both types are also assumed to pay taxes, and $\tau_k^a, \tau_k^o, \tau_w^s, \tau_w^{us}, \tau_w^{sk}$, and τ_l denote the capital income tax rate for agriculture, the capital income tax rate for others, the wage income tax rate for self-employed worker, the wage income tax rate for unskilled employed worker, the wage income tax rate for skilled employed worker, and the land tax rate, respectively. Note that all taxes are assumed to be proportional, and the tax rates have been calculated by using the actual social accounting matrix. The tax rate can be negative in the simulations if the effect of the case when the government subsidizes a particular factor input is explored. Note also that all factors are assumed to be immobile between different production sectors by assumption. The value of factor payments can be obtained from the actual social accounting matrix[xvi].

The first order conditions yield the demand functions such that:

$$X_i^h = X_i^h\left(\vec{p}, r_j^a, r_j^n, w_j^s, w_j^{us}, w_j^{sk}, LP_j; \tau_k^a, \tau_k^o, \tau_w^s, \tau_w^{us}, \tau_w^{sk}, \tau_l\right)$$

$$= \frac{\theta_i I^h (1 - s_p^h)}{p_i},$$

$$i = 1, 2, \ldots, 59, \quad h = a, b \tag{2}$$

where $\vec{p} = (p_1, p_2, \ldots, p_{59})$. Note that θ_i can be calculated by using (2) and the actual social accounting matrix so that:

$$\theta_i = \frac{p_i X_i^h}{I^h (1 - s_p^h)}; \quad h = a, b$$

where both the values of the denominator and the numerator can be obtained from the actual social accounting matrix.

<Production Sector>

Following the conventional assumption, the multiple decisions by each firm are described by the tree structure, where each firm is assumed to make a decision over several different items. In the tree structure, the optimal behavior of each firm which makes a decision over different items is described as if the firm always makes a decision over two different items at different steps. Each firm makes a decision over different items; exports of its own product, the amount of imported goods and intermediate goods used for its production, and labor and capital. This assumption simplifies a complicated decision over several items by each firm.

At step 1, a private firm, i, is assumed to use labor and capital to produce its composite goods, Y_i. Then, the firm is assumed to produce its domestic goods, Z_i, by using its own Y_i and $X_{i,k}$ at the second step. $X_{i,k}$ denotes the final consumption goods produced by firm k used by firm i for its production. Thus, $X_{i,k}$ is the amount of the final consumption goods produced by firm k for the intermediate production process of firm i. At the third step, the firm is assumed to decompose its domestic goods, Z_i, into exported goods, E_i, and final domestic goods, D_i. This step is concerned about its optimal decision over the amount of its product to be exported. At the final step (the fourth step), the firm is assumed to produce its final consumption goods, Q_i, by using its final domestic goods, D_i, and imported goods, M_i. This step corresponds to its optimal decision over how much it uses imported goods, M_i, and its own goods, D_i, to produce its final consumption goods, Q_i, which are consumed by domestic households. The assumption of this tree structure in terms of different decisions can incorporate firm's complicated decisions over exports of its own product, the amount of imported goods and intermediate goods which the firm uses in its production process, and the amount of factor inputs into the model in a tractable way.

Note that all market clearing conditions are used to determine all prices endogenously in their corresponding markets, and also that at each step the private firm is assumed to determine the amount of relevant variables in order to maximize its profit.

By the assumption of the above tree structure, all decision making processes can be simplified, and the optimal behavior about all different decisions can be incorporated as follows:

Step 1: The production of composite goods

Each firm is assumed to produce its composite goods by using capital and labor. Each firm is assumed to maximize its profit given by:

$$\max_{i} \; p_i^Y Y_i(Ka_i, Kn_i, Ls_i, Lusk_i, Lsk_i, La_i) - \sum_h \left(r_i^a Ka_i^h + r_i^n Kn_i^h + w_i^s Ls_i^h + w_i^{us} Lusk_i^h + w_i^{sk} Lsk_i^h + LP_i La_i^h \right) \tag{3}$$

where Y_i and p_i^Y denote the composite goods produced by firm i and its price, respectively. The production technology is given by:

$$Y_i(Ka_i, Kn_i, Ls_i, Lusk_i, Lsk_i, La_i) = Ka_i^{\varepsilon_{Ka,i}} Kn_i^{\varepsilon_{Kn,i}} Ls_i^{\varepsilon_{Ls,i}} Lusk_i^{\varepsilon_{Lusk,i}} Lsk_i^{\varepsilon_{Lsk,i}} La_i^{\varepsilon_{La,i}},$$

$$i = 1, 2, \ldots, 59, \tag{4}$$

where $\varepsilon_{Ka,i} + \varepsilon_{Kn,i} + \varepsilon_{Ls,i} + \varepsilon_{Lusk,i} + \varepsilon_{Lsk,i} + \varepsilon_{La,i} = 1$ is assumed for all $i = 1, 2, \ldots, 59$. It is also assumed such that:

$$\sum_h Ka_i^h = Ka_i, \quad \sum_h Kn_i^h = Kn_i, \quad \sum_h Ls_i^h = Ls_i,$$

$$\sum_h Lusk_i^h = Lusk_i, \quad \sum_h Lsk_i^h = Lsk_i, \quad \sum_h La_i^h = La_i.$$

Each firm is assumed to maximize (3) with respect to labor and capital subject to (4), and the first order conditions yield the demand functions such that:

$$Ka_i = Ka_i(p_i^Y, r_i^a, r_i^n, w_i^s, w_i^{us}, w_i^{sk}, LP_i; \alpha_{Ka,i}, \alpha_{Kn,i}, \alpha_{Ls,i}, \alpha_{Lusk,i}, \alpha_{Lsk,i}, \alpha_{La,i}) = \frac{\alpha_{Ka,i}}{r_i^a} p_i^Y Y_i,$$

$$Kn_i = Kn_i(p_i^Y, r_i^a, r_i^n, w_i^s, w_i^{us}, w_i^{sk}, LP_i; \alpha_{Ka,i}, \alpha_{Kn,i}, \alpha_{Ls,i}, \alpha_{Lusk,i}, \alpha_{Lsk,i}, \alpha_{La,i}) = \frac{\alpha_{Kn,i}}{r_i^n} p_i^Y Y_i,$$

$$Ls_i = Ls_i(p_i^Y, r_i^a, r_i^n, w_i^s, w_i^{us}, w_i^{sk}, LP_i; \alpha_{Ka,i}, \alpha_{Kn,i}, \alpha_{Ls,i}, \alpha_{Lusk,i}, \alpha_{Lsk,i}, \alpha_{La,i}) = \frac{\alpha_{Ls,i}}{w_i^s} p_i^Y Y_i,$$

$$Lusk_i = Lusk_i(p_i^Y, r_i^a, r_i^n, w_i^s, w_i^{us}, w_i^{sk}, LP_i; \alpha_{Ka,i}, \alpha_{Kn,i}, \alpha_{Ls,i}, \alpha_{Lusk,i}, \alpha_{Lsk,i}, \alpha_{La,i}) = \frac{\alpha_{Lusk,i}}{w_i^{us}} p_i^Y Y_i,$$

$$Lsk_i = Lsk_i(p_i^Y, r_i^a, r_i^n, w_i^s, w_i^{us}, w_i^{sk}, LP_i; \alpha_{Ka,i}, \alpha_{Kn,i}, \alpha_{Ls,i}, \alpha_{Lusk,i}, \alpha_{Lsk,i}, \alpha_{La,i}) = \frac{\alpha_{Lsk,i}}{w_i^{sk}} p_i^Y Y_i,$$

$$La_i = La_i(p_i^Y, r_i^a, r_i^n, w_i^s, w_i^{us}, w_i^{sk}, LP_i; \alpha_{Ka,i}, \alpha_{Kn,i}, \alpha_{Ls,i}, \alpha_{Lusk,i}, \alpha_{Lsk,i}, \alpha_{La,i}) = \frac{\alpha_{La,i}}{LP_i} p_i^Y Y_i,$$

$$i = 1, 2, \ldots, 59 \qquad (5)$$

Note that parameter values can be calculated by using from (5), and the actual social accounting matrix so that:

$$\alpha_{Ka,i} = \frac{r_i^a Ka_{i,}}{p_i^Y Y_i}, \quad \alpha_{Kn,i} = \frac{r_i^n Kn_{i,}}{p_i^Y Y_i}, \quad \alpha_{Ls,i} = \frac{w_i^s Ls_i}{p_i^Y Y_i},$$

$$\alpha_{Lusk,i} = \frac{w_i^{ys} Lusk_i}{p_i^Y Y_i}, \quad \alpha_{Lsk,i} = \frac{w_i^{sk} Lsk_i}{p_i^Y Y_i}, \quad \alpha_{La,i} = \frac{LP_i La_i}{p_i^Y Y_i},$$

$$i = 1, 2, \ldots, 59$$

Step 2: The production of domestic goods

Each firm is assumed to produce domestic goods, Z_i, by using intermediate goods and its own composite goods, which production has been described at step 1. The optimal behavior of each firm in terms of the production of domestic goods can be described such that:

$$\underset{Y_i, X_{i,j}}{Max} \quad \pi_i = p_i^Z Z_i - \left(p_i^Y Y_i - \sum_{k}^{59} p_k^X X_{i,k} \right),$$

$$st \quad Z_i = \min\left(\frac{X_{i,k}}{ax_{i,k}}, \frac{Y_i}{ay_i} \right), \quad i = 1, 2, \ldots, 59,$$

where $X_{i,k}$ and p_k^X denote an intermediate good k used by firm i and its price, respectively. p_i^Z is the price of Z_i. $ax_{i,k}$ denotes the amount of an intermediate good k used for producing one unit of a domestic good of firm i, and ay_i denotes the amount of its own composite good for producing one unit of its domestic good. Note that the production function at this step is assumed to be the Leontief type. Using $ax_{i,k}$ and ay_i, and assuming that the market is fully competitive, the zero-profit condition can be written by:

$$p_i^Z = p_i^Y ay_i + \sum_{k=1}^{59} p_k^X ax_{i,k}, \quad i = 1, 2, \ldots, 59.$$

Step 3: Decomposition of Domestic Goods into Exported Goods and Final Domestic Goods

The optimal decision made by firm i in terms of the amount of exports of its own goods is described as the decomposition of Z_i ($i = 1, 2, \ldots, 59$) into exported goods, E_i , and final domestic goods, D_i . Each firm is assumed to maximize its profit such that:

$$\pi = p_i^e (1 - \tau_i^e) E_i + p_i^d D_i - (1 + \tau_i^Z) p_i^Z Z_i, \tag{6}$$

where p_i^e and p_i^d denote the price when the domestic goods are sold abroad, and the price when the domestic goods are sold domestically, respectively. Note that p_i^e is measured in the domestic currency. τ_i^Z and τ_i^e are the tax rates of a production tax imposed on the production of Z_i , and the tax rate on exports, respectively. The values of τ_i^Z and τ_i^e are calculated by using the actual social accounting matrix. The decomposition is assumed to follow the Cobb-Douglas technology such that[xvii]:

$$Z_i = E_i^{\alpha_i^e} D_i^{\alpha_i^d}, \quad i = 1, 2, \ldots, 59, \tag{7}$$

where $\alpha_i^d + \alpha_i^e = 1 \; (i = 1, 2, \ldots, 59)$ is assumed. Each firm is assumed to maximize (6) with respect to E_i and D_i subject to (7), and the first order conditions yield

$$E_i = E_i(p_i^e, p_i^d, p_i^Z; \tau_i^Z, \tau_i^e, \alpha_i^e, \alpha_i^d) = \frac{\alpha_i^e (1 + \tau_i^Z) p_i^Z Z_i}{p_i^e (1 - \tau_i^e)},$$

$$D_i = D_i(p_i^e, p_i^d, p_i^Z; \tau_i^Z, \tau_i^e, \alpha_i^e, \alpha_i^d) = \frac{\alpha_i^d (1 + \tau_i^Z) p_i^Z Z_i}{p_i^d}, \quad i = 1, 2, \ldots, 59. \tag{8}$$

Note that α_i^e and α_i^d can be calculated by using (8) and the actual social accounting matrix so that:

$$\alpha_i^e = \frac{p_i^e (1 - \tau_i^e) E_i}{(1 + \tau_i^Z) p_i^Z Z_i},$$

$$\alpha_i^d = \frac{p_i^d D_i}{(1 + \tau_i^Z) p_i^Z Z_i}, \quad i = 1, 2, \ldots, 59,$$

where $p_i^e E_i$, $p_i^d D_i$, $p_i^Z Z_i$, $\tau_i^Z p_i^Z Z_i$, and $\tau_i^e p_i^e E_i$ can be obtained from the actual social accounting matrix.

Step 4: The Production of the final goods

Denote the final consumption goods by Q_i ($i = 1, 2, \ldots, 59$). The final consumption goods are assumed to be produced by using the final domestic goods, D_i , and the imported goods, M_i . This step corresponds to the optimal decision making behavior of each firm in terms of the amount of imported goods which are used in its production process. The production technology at this final step is given by the following Cobb-Douglas function:

$$Q_i = M_i^{\beta_i^m} D_i^{\beta_i^d}, \quad i = 1, 2, \ldots, 59, \tag{9}$$

where $\beta_i^m + \beta_i^d = 1 \; (i = 1, 2, \ldots, 59)$ is assumed. Each firm is assumed to maximize its profit with respect to M_i and D_i subject to (9). Its profit is given by:

$$\pi = p_i^Q Q_i - (1 + \tau_i^m) p_i^m M_i - p_i^d D_i, \quad i = 1, 2, \ldots, 59,$$

where p_i^Q and τ_i^m denote the price of its final consumption goods, Q_i, and the import tariff rate, respectively. The import tariff rate is calculated by using the actual social accounting matrix. Then, the first order conditions yield

$$M_i = M_i\left(p_i^m, p_i^d, p_i^Q; \tau_i, \alpha_i, \beta_i\right) = \frac{\beta_i p_i^Q Q_i}{(1-\tau_i)\psi_i^m},$$

$$D_i = D_i\left(p_i^m, p_i^d, p_i^Q; \tau_i, \alpha_i, \beta_i\right) = \frac{\alpha_i p_i^Q Q_i}{p_i^d}, \quad i = 1, 2, \ldots, 59. \tag{10}$$

Note that α_i and β_i can be calculated by using (10) and the actual social accounting matrix so that:

$$\alpha_i = \frac{(1-\tau_i)\psi_i^m M_i}{p_i^Q Q_i},$$

$$\beta_i = \frac{p_i^d D_i}{p_i^Q Q_i}, \quad i = 1, 2, \ldots, 59,$$

where $p_i^m M_i$, $p_i^d D_i$, $p_i^Q Q_i$ and $\tau_i p_i^m M_i$ can be obtained from the actual social accounting matrix.

<The Government>

The government is assumed to impose several taxes to satisfy its budget constraint. Its budget constraint is given by:

$$\sum_{i=1}^{59} p_i^Q X_i^g + S^g + Gimp + GTrans = T^I + T^p + T^m + T^e + Gex,$$

where the left hand side is the total government expenditure, and the right hand side is the total government revenue. X_i^g and S^g denote government consumption of a final consumption good i, and government savings, respectively. $GTrans$ denotes the total amount of income transfers to both types of h such that:

$$GTrans = \sum_{h} GTrans^h.$$

$Gimp$ and Gex denote direct imports and exports by the government, respectively. The total tax revenue is given by:

$$T^I = \sum_{i=1}^{59} \sum_{h} \left(\tau_i^s w_i^s Ls_i^h + \tau_i^{us} w_i^{us} Lusk_i^h + \tau_i^{sk} w_i^{sk} Lsk_i^h\right)$$

$$+ \sum_{i=1}^{59} \sum_{h} \left(\tau_i^a r_i^a Ka_i^h + \tau_i^n r_i^n Kn_i^h\right)$$

$$T^L = \sum_{i=1}^{59} \sum_{h} \left(\tau_i^L LP_i La_i^h\right)$$

$$T^p = \sum_{i=1}^{59} \left(\tau_i^p p_i^Z Z_i\right)$$

$$T^m = \sum_{i=1}^{59} \left(\tau_i^m p_i^m M_i\right)$$

$$T^e = \sum_{i=1}^{59} \left(\tau_i^e p_i^e E_i\right)$$

where T^I, T^L, T^p, T^m, and T^e denote the total income tax revenue, the total land tax revenue, the total production tax revenue, the total import tariff revenue, and the total export tax revenue, respectively. The government is assumed to save the constant amount relative to the total amount of tax revenue, and the government savings are assumed to be given by

$$S^g = s^g (T^I + T^p + T^m + Gex)$$

where the constant ratio, s^g, is given exogenously, and its value has been calculated by using the actual SAM.

<Equilibrium Conditions>

There are two factor inputs, labor and capital. Since the model is static and thus the short-run effect is explored, it is assumed that each factor cannot move among different sectors (industries) in the short-run. This implies the equilibrium conditions of factor markets such that

$$\begin{aligned} \overline{Ka}_i^a + \overline{Ka}_i^b &= Ka_i, \\ \overline{Kn}_i^a + \overline{Kn}_i^b &= Kn_i, \\ \overline{Ls}_i^a + \overline{Ls}_i^b &= Ls_i, \\ \overline{Lusk}_i^a + \overline{Lusk}_i^b &= Lusk_i \\ \overline{Lsk}_i^a + \overline{Lsk}_i^b &= Lsk_i \\ \overline{La}_i^a + \overline{La}_i^b &= La, \\ i &= 1, 2, \ldots, 59 \end{aligned} \tag{11}$$

Note that $r_i^a, r_i^n, w_i^s, w_i^{us}, w_i^{sk}$, and LP_i $(i = 1, 2, \ldots, 59)$ are determined in order to satisfy (11).

In terms of the market clearing condition of a good i $(i = 1, 2, \ldots, 59)$, a private investment sector is introduced in order to close the economy in this paper[xviii]. Denoting the amount of a good i consumed by the private investment sector by X_i^s, the market clearing condition of a good i is given by:

$$Q_i = X_i^a + X_i^b + X_i^g + X_i^s + \sum_{k}^{59} X_{i,k}, \quad i = 1, 2, \ldots, 59,$$

where the left hand side is the total supply, and the right hand side is the total demand for a good i. p_i^Q $(i = 1, 2, \ldots, 59)$ is determined in order to satisfy (16). Note that the budget constraint of the private investment sector is given by:

$$\sum_{i=1}^{59} p_i^Q X_i^s = S^g + S_p^a + S_p^b + S^f,$$

where the left hand side is the total amount of its consumption, and the right hand side is the total amount of its income. S^f denotes the total amount of savings by the foreign sector, or the deficits in the current account, and it is given by subtracting exports from imports[xix]. Since both the amount of exports and the amount of imports can be obtained from the actual social accounting matrix, S^f can be calculated from the actual social accounting matrix, and thus it is exogenously given in the model. Furthermore, the foreign trade balance is given by

$$\sum_{i=1}^{59} p_i^{w,e} E_i + S^f + Gex + \sum_{h} Rm^h = \sum_{i=1}^{59} p_i^{w,m} M_i + Gimp,$$

where $p_i^{w,e}$ and $p_i^{w,m}$ denote the world price of an export good, and an import good of i, respectively, and both of them are assumed to be given exogenously. Since p_i^e and p_i^m are both measured in the domestic currency, they are also expressed such that:

$$p_i^e = e\,p_i^{w,e},$$

$$p_i^m = e\,p_i^{w,m}, \quad i = 1, 2, \ldots, 59,$$

where e denotes the exchange rate. Note that the exogeneity assumption on the world prices implies that the exchange rate is endogenously determined within the model.

Notes

[i] The World Bank (2006) also pointed out that the true size of remittances flows through formal and informal channels may be much higher than the formal size by perhaps 50 percent or more. This implies, as many researchers have recognized, that the impact of remittances on the world economy is getting more important.

[ii] All survey data conducted in the past (Ghana Living Standards Survery (GLSS) round 3 (1991/1992), 4 (1998/1999), and 5 (2005/2006) showed the Gini Coefficient improved over time until GLSS 6 (2012/2013) was produced.

[iii] Agbola (2013) also found the same result for Ghana in his empirical study.

[iv] Freund & Spatafora (2008) examined the impact of the transaction cost on remittances, and Mamun et al. (2015) recently argued that the development of the financial sector is important for stimulating remittances.

[v] Adams & Cuecuecha (2010) investigated the same issue for Guatemala, and they reached the same result. Kabki et al (2004) investigated the behavior of households regarding how to spend remittances for Netherlands-based Ghanaian migrants based on interviews, and they also concluded that remittances would be spent mainly on investment goods such as housing and family business in the country of origin.

[vi] While the context is different, Adams (2009) found an inverted U-shaped relationship between per capita GDP and per capita remittances, and also found out that more skilled (educated) migrants remit less. Faini (2007) also obtained the same result. Mckenzie & Rapoport (2007) explicitly studied the network effect, which is smiliar to the externality effect in Taylor (1992), and they also found an inverted U-shaped curve between the number of migrants and inequality.

[vii] Docquier et al. (2007) estimated the determinants of the brain drain, and they argued that not only the physical distance but also political instability would be key elements.

[viii] Guha (2013) constructed a DSGE model to investigate the Dutch Disease effect of remittances.

[ix] Our SAM can be provided upon request.

[x] The total value of exports of sector 51 was 7492.086 billion in GHC (old Ghana Cedis), which is equal to 173.21 million US dollars, in the original input-output table of year 2005. This size is relatively very large compared to the amount of exports of other sectors due to the fact that it contains private transfers from abroad. Then, this amount is assumed to be treated as informal remittances in the paper.

[xi] The detailed model is given in Appendix.

[xii] There are obviously other negative impacts of the brain drain from the 'health' sector on the country of origin such as the hygiene level and the mortality rate of the country. Such impacts cannot be included in our analysis.

[xiii] Table 8 shows the result based on the assumption that increased remittances are used for more consumption of only education, housing, and health goods.

[xiv] The assumption that the ratio is exogenously given is made only for the model to be consistent to the actual social accounting matrix, and this assumption is very common in the literature.

[xv] Preciously speaking, $Trans^h$ also includes self-consumption within the same group.

[xvi] The total number of self-employed as well as employed workers in each production sector can be obtained from the IO table of year 2005. Since per capita wage income of employed workers and total wage income can also be obtained from the IO table of year 2005, $w_{j,h}L_h^j$ can be calculated for both h sw and h ew. On $r_{j,h}\overline{K}_h^j$, the ratio of the number of each type of workers has simply been used to divide the total capital income of each production sector.

[xvii] While it is common in the literature to assume (7) and (9) to be expressed by the CES technology, it is assumed in this paper that both technologies are expressed by the Cobb-Douglas technology. While the Cobb-Douglas function is the special case of the CES function and thus the CES function provides more generality, our assumption gives us more advantages in terms of preciseness of our benchmark model. As our benchmark results show, the assumption of the Cobb-Douglas technology substantially contributes to our perfectly well-fitted benchmark result. We believe that the benchmark model should be well-fitted to re-produce the actual economy within the model in any simulation analysis, and the Cobb-Douglas technology is assumed at the sacrifice of a certain level of generality, in order to obtain our perfectly well-fitted benchmark model.

[xviii] This is also the conventional assumption in the literature.

[xix] The FDI is assumed to be negligible in this paper.

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