

Aid, Foreign Direct Investment and Economic Development

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Contents

Introduction.....	7
1 Foreign Aid: Optimal Allocation and the Role of the Relative price.....	27
1.1 Introduction.....	27
1.2 The model.....	31
1.2.1 The basic structure.....	31
1.2.2 The central planner problem.....	33
1.2.3 The steady state paths: existence and comparative static.....	35
1.3 Dynamics.....	38
1.3.1 Optimal allocation under aid acceleration.....	42
1.4 Results and discussion.....	46
1.5 Conclusions.....	49
2 Lagged Aid, Flexible Labor Supply and Optimal Growth.	51
2.1 Introduction.....	51
2.2 The model.....	55
2.2.1 Technology.....	57
2.2.2 The central planner problem.....	57
2.2.3 The steady state paths: existence.....	60
2.3 A numerical example.....	61
2.4 Dynamics.....	64
2.5 Concluding remarks.....	68

3 Foreign Direct Investment, Host-Wage Inequality and Economic Development.....	71
3.1 Introduction.....	71
3.2 The model.....	75
3.2.1 The central planner problem.....	79
3.2.2 The steady state paths.....	81
3.3 Dynamics.....	83
3.4 Robustness analysis.....	96
3.5 Concluding remarks.....	100
Appendix A: Dynamic system models.....	103
Appendix B: Tables.....	105
Bibliography.....	109

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Introduction

This thesis is intended to contribute to the development economic literature in two ways. Firstly, it introduces a new methodology to deal with the *foreign aid problem* and its host-country macroeconomic consequences. This is certainly an important topic that deserves attention because of the huge amount of funds that International Organizations such as the World Bank and the IMF as well as donors move each year to help developing countries, without so far much success.

Controversies about aid effectiveness go back decades. Influential critics such as Milton Friedman, Peter Bauer, and Williams Easterly have leveled stinging critiques, claiming that aid has enlarged government bureaucracies, perpetuated bad governments, enriched the elite in poor countries, or just been wasted. They cite widespread poverty in Africa and South Asia despite three decades of aid, and point to countries that have received substantial aid yet have had disastrous records -such as the Democratic Republic of the Congo, Haiti, Papua New Guinea, and Somalia. In their eyes, aid programs should be dramatically reformed, substantially curtailed, or eliminated altogether.

Supporters counter these arguments are overstated. Big names such as Jeffrey Sachs, Joseph Stiglitz, Nicholas Stern, and others have argued that, although aid has sometimes failed, it has supported poverty reduction and growth in some countries and prevented worse performance in others. They believe that many of the weaknesses of aid have more to do with donors than recipients, especially since much of aid is given to political allies rather than to support development. They point to a range of successful countries that have received significant aid such as Botswana,

Indonesia, Korea, and, more recently, Tanzania and Mozambique, along with successful initiatives such as the Green Revolution, the campaign against river blindness, and the introduction of oral rehydration therapy. In the forty years since aid became widespread, they say, poverty indicators have fallen in many countries worldwide, and health and education indicators have risen faster than during any other 40-year period in human history.

Throughout this debate, however, we can clearly distinguish three prevailing views on aid and growth:

Aid has no effect on growth, and may actually undermine growth.

There are several reasons why aid might not support growth. It can be wasted on frivolous expenses -such as limousines or presidential palaces-, or it can encourage corruption. Further, it can undermine incentives for private sector production, including by causing the currency to appreciate, which weakens the profitability of tradable goods production. Similarly, food aid, if not managed appropriately, can reduce farm price and hurt farmer income. Aid flows potentially can undermine incentives for both private and government saving. They can also sustain bad governments in power, helping to perpetuate poor economic policies and postpone reforms.

This view has been supported by a range of empirical studies, mostly published from the early 1970s through the mid-1990s.¹ The main methodological aspects involved in these works consider only a simple linear relationship between aid and growth in which each dollar of aid has exactly the same impact on growth as the first, so eliminating the possibility of diminishing returns. Further, they ignore possible endogeneity of aid in which faster growth might attract higher aid, among other issues.

¹ In Chapters 1 and 2, we cite the most influential (and others) references on this point.

Aid has a positive relationship with growth on average (although not in every country), but with diminishing returns.

Aid could support growth by financing investment or by increasing worker productivity (for example, through investments in health and education). It can bring new technology or knowledge, either imbedded in capital goods imports or through technical assistance. Several studies found a positive relation between aid and growth, but this strand of the literature took a significant turn in the mid-1990s when researchers began to investigate whether aid might spur growth with diminishing returns, that is, that the impact of additional aid would decline as aid amounts grew.² Oddly, since economic theory and research had recognized the importance of diminishing returns on investment since the 1950s, research on aid and growth testing only a linear relationship persists even today.

Aid has a conditional relationship with growth, helping to accelerate growth only under certain circumstances.

The “conditional” view usually argues that aid effectiveness hinges on either recipient characteristics or donor practices. On the recipients’ side, World Bank researchers Jonathan Isham, Daniel Kaufmann and Lant Pritchett opened this line of enquiry in 1995 by finding that World Bank projects had higher rates of returns in countries with stronger civil liberties. Craig and Burnside (2000) followed with their influential study that concluded that aid stimulated growth in countries with “good” policies, but not otherwise. Others have proposed different characteristics that might affect the aid-growth relationship, including vulnerability to trade shocks, climate, institutional quality, political conflict, and geography. However, the statistical results of these studies tend to be fragile and subsequent research has questioned some of the results.

² Surprisingly, most researchers claiming this point belong to the staff of the IMF and their studies typically do not conclude that aid has always worked, but rather that, on average, higher aid flows have been associated with more rapid growth.

Nevertheless, the view that aid works only in countries with good policies and institutions has become the conventional wisdom among donors. The appeal of this approach is that it can explain why aid seems to have supported growth in some countries but not others. According to Radelet (2003), this reasoning has had an enormous impact on donors, especially the multilateral development banks, and the U.S. Millennium Challenge Account.

On the donors' side, multilateral aid might be more effective than bilateral aid, and untied aid is thought to have higher returns than aid tied to purchases in the donor country. Donors with large bureaucracies, heavy reporting requirements, or ineffective monitoring and evaluation systems probably undermine the effectiveness of their own programs. Two influential and overlapping views argue that aid is more effective when donors allow for greater "country ownership" or broader "participation" in setting priorities and designing programs. In other words, it is expected that country ownership allows for the recipient country to have a stronger say in these decisions; broader participation allows civil society and faith-based and nongovernmental organizations to have a voice alongside the government in these choices. These issues have been regularly debated and have begun to change donor practices, but have been subject to little systematic research.

In this context, and motivated by this hot and open debate, we offer in these essays a new approach to tackle this problem.

Our methodology, which builds on the standard optimal growth framework under rational expectations, presents advances in several aspects relative to the existing literature. Qualitatively speaking, it offers a fresh view to undertaking the study of the connection between aid effectiveness and economic growth. Until now, the classical way of studying this kind of problem has been to use one-sector models in which aid is taken as an exogenous variable. In contrast, we claim that a comprehensive analysis of the macroeconomic impact of aid should take into account the *sectoral* composition of the economy. In addition, we endogenize the allocation of aid across sectors. This approach allows us to capture what is

one of the basic goals of our research, namely, to know more accurately how much of aid has been used or not for the production of *durable* goods. Put in another way, we do think that any model intended to shed some lights on the likely aid-growth connection ought, at least, to suggest an answer about where most aid flows could be. Another relative advance of our methodology is that of that it attempts to interpret the evidence on aid in terms of *forward-looking dynamics* models. In the words of Obstfeld (1999), this strategy is consistent with the fact that “*plainly a measure of the economy’s distance from the steady state could be essential for getting an estimate of the actual effects of aid on consumption, saving, and investment*”. As claimed by this author, one of the main disadvantages of the very influential Boone’s (1996) study is that of that his estimates throw little or no light on the effects of aid on developing countries because of they are just valid at the steady state (i.e., nothing is said about the effect of aid on countries that are still in transition). To the best of our knowledge, Obstfeld’s study is the only work which is consistent with the perspective we adopt in this thesis on this particular point. Speaking now in quantitative terms, we would highlight the issue that at least one of the two of our models *fully replicates* the main stylized facts outlined in the literature. This accordance with reality suggests that our framework may be viewed as methodologically attractive to study this problem. At this point, it is worth mentioning here that, accordingly to Easterly (1999), models based on the standard Harrod-Domar’s study are *still* applied for International Organizations in order to assess short-term investment requirements for a target growth rate even though this kind of approach was supposed dead since long ago!³ Additionally, our methodology yields significant structural information. Notably, it accounts of significant causal mechanisms that would explain the allocation of aid across sectors which have not been addressed before. These issues are reported throughout the body of this thesis.

Furthermore, although our models have been calibrated for specific countries, applications to a larger class of situations are feasible.

³ See, e.g., Chenery and Bruno (1962), Adelman and Chenery (1966), Chenery and Strout (1966), and Chenery and Eckstein (1970).

On a different point, this thesis makes also a contribution to the foreign direct investment (FDI) literature. This is another attention-worthy topic in development economics. At this point, since the FDI literature is so vast, let us restrict the analysis by offering now an overview of FDI in Latin America and the Caribbean.

FDI inflows to Latin America and the Caribbean

Table 1 shows FDI inflows to Latin America and the Caribbean (excluding financial centers) during the period 1991-2005.

Table (i)
LATIN AMERICA AND THE CARIBBEAN: NET FDI INFLOWS BY
SUBREGION, 1991-2005

(millions of dollars)

	1991- 1995	1996- 2000	2001- 2003	2004	2005
Mexico	6804.6	12608.8	18805.8	18244.4	17804.6
Central America	659.2	2340.2	2250.7	2726.8	2745.0
Caribbean	945.1	2519.1	2857.9	2861.2	2971.3
Subtotal - Mexico and the Caribbean Basin	8406.9	17468.1	23914.4	23834.3	23520.8
MERCOSUR	6445.2	36757.1	19863.1	22822.1	20398.5
Andean Community	3685.5	10746.7	9701.1	7674.0	16918.5
Chile	1666.2	5667.0	5067.7	7172.7	7208.5
Subtotal – South America	11797.0	53170.7	34671.9	37668.8	44525.4
Total – Latin America and the Caribbean	20205.8	70638.9	58586.2	61503.2	68046.3

Source: Economic Commission for Latin America and the Caribbean (ECLAC) on the basis of statistics from the IMF and official figures (annual averages). Net inflows are defined as FDI inflows to the reporting economy minus capital outflows generated by the same foreign companies.

Three major trends can be observed from this table. First, total inflows rose by a factor of 3.5 during the period 1996-2000 respect to 1991-1995 before falling sharply thereafter. Then, they began to rebound, surpassing the

US\$68 billions mark. Second, South America has received more FDI than Mexico and the Caribbean Basin, but it has also experienced much more volatility, in part because much of its inward FDI has been related to one-off privatization. Third, the winners and losers for 2005 (compared to 2004) are clear: the Andean Countries (especially Colombia, but excepting Bolivia), Argentina, the Dominican Republic, Nicaragua and Uruguay are in the first category, while Bolivia, Brazil and Honduras are in the latter. In other words, it is observed that the absolute level of FDI inflows continues to be variable and its distribution is uneven, although, when weighted by GDP, there is clearly a convergence between the subregions in this respect.

Both major subregions of Latin America and the Caribbean – Mexico/the Caribbean Basin and South America - receive FDI of all types, but there have traditionally important differences in emphasis. Mexico and the Caribbean basin tend to receive proportionally more efficiency-seeking FDI aimed at establishing export platforms for manufactures, while South America receives a larger proportion of market-seeking FDI in both services and manufactures. Although an incipient trend towards more efficiency-seeking operations has been observed in Brazil in the electronics and automotive industries, it remains to be seen whether this trend will persist, given the revaluation of the Brazilian *real*. As regards geographical origin, more FDI in Mexico and the Caribbean comes from the USA, whereas in South America, the largest share comes from European countries. There are also some important differences within these subregions.

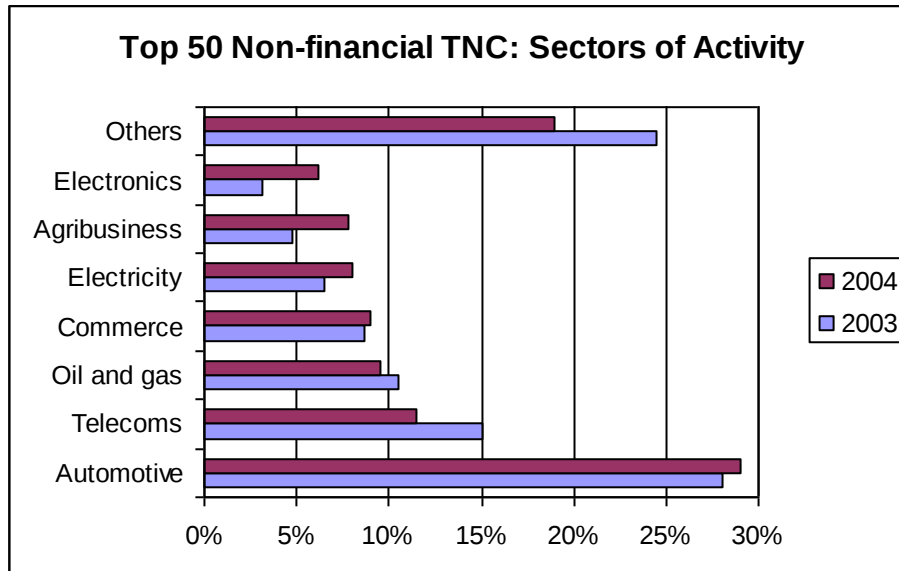
These characteristics of inward FDI are also reflected in the international competitiveness of the two subregions, although FDI is clearly not the only factor involved. On the one hand, Mexico and the Caribbean Basin experienced solid growth in the international market shares in 1980-2004, especially with regard to non-resource-based manufactures, although this trend has weakened somewhat since 2002. FDI in export platforms for the electronics, automotive and apparel industries accounts for much of this export success, even though these investment flows are also associated with some of the recent difficulties that have arisen as FDI export platforms in China crowd out some of this subregion's sales on the US market. South

America, on the other hand, has specialized in natural resources and natural-resource-based manufactures, in which FDI is not so important a factor. The long-term international market shares of South America have not increased nearly as much as those of Mexico and the Caribbean Basin, although the high international prices of several commodities (petroleum, copper, gold, soybeans) did have the effect of expanding the international market shares of South America in 2002-2004. Thus, FDI plays a very important role in relation to the Mexican and Caribbean Basin subregion's international competitiveness but is less influential –but by no means unimportant- with regard to the international competitiveness of South America.

The presence of Transnational Corporations (TNCs) in Latin America is clearly reflected in their position on the list of the 500 top enterprises by sales and the top 200 principal exporters. In fact, consolidated sales of the principal subsidiaries of the 50 largest TNCs operating in the region amounted to US\$ 258.6 billion in 2004. United States companies still lead the list, with 22 firms, although European companies, taken together, have 24 affiliates. Three Asian companies and one Australian firm make up the balance. In all, 31 of the companies are manufacturers, 11 are service providers and 7 specialize in natural resources. The manufacturers are concentrated in the automotive industry (9), food products and beverages (7) and electronics (6). The services providers deal mainly in telecommunications (4), electricity (3) and retail trade (3). Five of the seven natural-resource- based companies are petroleum/gas producers, while the other two are mining companies.

In short, TNCs have maintained a significant presence in Latin American and Caribbean, but their position has been slipping somewhat over the last few years.

Figure (i)



Thus, the Latin American and Caribbean region's experience with FDI can be summed up as follows. During the 1990s, Latin America and the Caribbean were quite successful in attracting large amount of FDI based on new economic models that focused on opening up the economy, liberalizing business activities in the form of the deregulation of services and the privatization of State enterprises. Those initiatives attracted mostly market-seeking and natural-resource-seeking FDI. The region did not perform as well in attracting efficiency-seeking and, especially, strategic or technological asset-seeking FDI, which are associated with the globalization of TNC activities.

A growing debate has arisen about the benefits of the FDI received by Latin America and the Caribbean. On the one hand, FDI inflows have played an important role in transforming the region by modernizing industries and improving services and infrastructure. This effect is evident, for example, in the upgraded telecommunications network in Brazil, financial services in Argentina, road and airport in Chile and the export platforms in Mexico and Costa Rica that assemble competitive motor vehicles and microprocessors, respectively. On the other hand, serious problems have

arisen in different parts of the region with regard to FDI. *Natural-resource-seeking* FDI is criticized for creating enclave industries entailing few of the types of processing activities that would help integrate these investments into the national economy, as well as for generating low fiscal revenues from non-renewable resources and polluting the environment. *Market-seeking* FDI is often regarded as creating higher-cost industrial activities that, although not internationally competitive, sometimes crowd out local firms, as well as services prone to regulatory problems that at times trigger formal investment disputes. *Efficiency-seeking* FDI is criticized because it often results in a low-value-added trap based on static rather than dynamic advantages, has only weak production linkages with the local economy, crowds out local firms and lead to a “race to the bottom” in terms of production costs (wages, social benefits) and a “race to the top” with regard to incentives (taxes and infrastructure). Finally, *technological-seeking* FDI (which is almost non-existent in the region) can stagnate at a low level of scientific and technological development and can come into tension with national scientific and technological policy goals. In other words, the FDI boom in Latin America and the Caribbean produced mixed results and, as FDI inflows decline, criticism of those results increases.

The Latin American and Caribbean experience illustrates the fact that while FDI by TNCs can lead to increased productivity and export, it does not necessarily boost the domestic sector’s competitiveness, which is what ultimately determines long-term economic growth. Economic liberalization allows TNCs to tap into existing capabilities more freely but does not, in itself, provide growth opportunities unless the domestic industrial sector has the necessary absorptive capacity to profit from the externalities generated by TNCs activity. As a consequence, over time, FDI inflows from TNCs rise in countries where local capabilities strengthened and new capabilities are created, but they stagnate or fall in economies where this does not happen. For this reason, the Economic Commission for Latin America and the Caribbean (ECLAC) recommends in its FDI (2005) Report (Spanish version) that it is essential to connect the competitive advantages of TNCs to the improvement of the domestic absorptive capacity of host economies. As we

shall see later, one of the central policy-suggestions of my thesis is fully in accordance with this statement.

Active FDI policies

While FDI can be attracted in a number of different ways, recent experience suggests that the more successful countries employ active or integrated strategies to do so. Active policies are based on prioritizing certain types of FDI and then creating the necessary conditions to attract them (availability, cost and quality of production), whereas passive policies rely mainly on the natural resource base, legal and institutional conditions, and on certain types of measures to facilitate FDI. The former usually target higher-quality (often efficiency-seeking or strategic asset-seeking) FDI within a coordinated policy framework focusing on productive development. By contrast, the latter policies tend to attract natural-resource -or market-seeking- FDI and to be independent of other policies. An integrated approach in this area, on the other hand, involves linking FDI and other productive development strategies directly to the national development strategy.

Governments around the world are now tending to move towards the use of more active and more focused investment policies. These policies are aimed at promoting both foreign and national investment by providing more effective way to compete for higher-quality FDI, on the one hand, and by improving the domestic absorptive capacity of the host economy, on the other. This trend is evident in developed countries (mainly European nations, such as Ireland, the Nordic countries, France, the UK), transition economies (e.g., Hungary, Czech Republic) and developing Asian countries (e.g., Singapore, Republic of Korea, China, Malaysia, Thailand). More recently, there is evidence of a further shift from active to integrated FDI policies, that is, the harmonization of FDI policy within overall development policy. National investment promotion agencies (IPAs) often play a central role in helping countries to reach their policy goals, especially in terms of attracting higher-quality FDI.

The situation in Latin American and the Caribbean does not, however, reflect these global tendencies. Instead, FDI policy in this region seems to have remained in its infancy, in the sense that FDI policies are primarily passive and most national IPAs are new and lack experience. While the mere existence of an IPA is not a guarantee of success, the experiences of the above-mentioned European, Asian and transition economies suggest that an effective IPA can be a critical element in attracting higher-quality FDI and deriving greater benefits from existing FDI. This assumes that other crucial elements for TNC investment decisions are in place, such as sufficient domestic absorptive capacity as reflected in a suitable business environment and the availability of qualified workers and local input suppliers.

The more competitive IPAs of Europe, Asia and some transition economies often use targeted incentives to make their economies more attractive, in particular to the efficiency-seeking and strategic or technological asset-seeking FDI that they prioritize. The most common incentives take the form of fiscal measures (tax relief) or financial benefits (direct subsidies to reduce set-up costs). In Latin American and the Caribbean, in contrast, existing incentives are primarily fiscal in nature and tend to be general, horizontal and automatic measures, usually involving export processing or *maquila* services and corporate tax rates. Moreover, there appears to be little evaluation in the region of how effective these incentives are in terms of their stated objectives. The IPAs of Latin America and the Caribbean recognize the importance of incentives, especially to both promote local investment and attract higher-quality FDI, but they have little experience with targeted incentives. The experience of other regions suggests that more active policies utilizing targeted incentives instead of horizontal ones could improve the quality of FDI that Latin American and the Caribbean region attracts and the benefits that it derives from these investments.

More active policies do not guarantee success in attracting higher-quality FDI or improving the benefits for the host country, though. This has been clearly demonstrated by the incentives war waged among various Brazilian

states in an attempt to attract the major new FDI projects being launched by automotive TNCs during the 1990s, to cite just one example. Poorly designed and badly implemented active policies may, in fact, prove to be more costly than passive ones, especially if local authorities do not possess a clear idea of their country's FDI potential in the context of absorptive capacity or of the differences between the social and private costs and benefits of large FDI projects. In my view, governments contemplating such policies would therefore do well to ensure that their FDI strategy sets out clear objectives and is realistic in terms of domestic absorptive capacity.

Governments considering the use of more active policies to attract higher-quality FDI must determine whether or not they possess what the TNCs that they are targeting are looking for (for example, access to exports markets, good quality and low-cost human resources, physical infrastructure, local inputs, and service logistics in the case of efficiency-seeking FDI, or the requisite scientific base, scientific infrastructure and intellectual property protection in the case of strategic asset-seeking FDI). This would enable Latin American and the Caribbean countries to begin to close the policy gap with competing host countries, especially those that have been most successful in attracting higher-quality FDI and benefiting more from. In this, policy definitely matters.

FDI in research and development

The recent UNCTAD report on global investment flows, the World Investment Report 2005 (WIR05), gives a detailed account of the tendency for transnational enterprises to internationalize their R&D activities. This segment of corporate value chains, which is the least internationalized, is now the fastest growing. Although comprehensive data are not available, the statistics show that:

- In 1995-2003, the foreign proportion of R&D spending by leading Swedish firms increased from 22% to 45% and amounted to US\$ 2.47 billion.

- Between 1995 and 2002, Japanese firms' external spending on R&D rose from US\$ 1.9 billion to US\$3.3 billion, which represented 4% of Japan's total R&D investment.
- German firms' external spending on R&D increased by 130%, to US\$ 12 billion, between 1995 and 2001.

The bulk of world spending on R&D is carried out by transnational firms. In 2002, the 700 companies that spend most on R&D (of which at least 98% are TNCs) accounted for 69% of total R&D spending by firms worldwide which, in turn, represented 46% of all spending on R&D in the world. To put these figures in context, Ford Motor spends more on R&D than Spain or Switzerland, Siemens spends more than Belgium or Israel, and Toyota more than Finland or Austria. Of these firms, 80% are based in five countries —the United States, Japan, Germany, the United Kingdom and France— and represent three main industries, IT hardware, automobiles, and pharmaceuticals and biotechnology.

R&D investment has traditionally gone to developed countries, and they continue to account for much of it. TNCs are increasingly locating R&D activities in developing countries, however. China and India are the principal Asian beneficiaries of R&D investments and Brazil is the largest Latin American recipient. Despite the opportunities this trend represents, however, as a rule the countries of the region have not actively promoted this type of investment. A recent survey conducted by UNCTAD (2005b) indicated that only 11% of IPAs in Latin America and the Caribbean promote investments in R&D, as against 79% in the developed countries and 94% in the developing countries of Asia and Oceania.

Table (ii)
Do IPAs Actively Promote R&D-Related FDI?

Region	Number of Responses	
	YES	NO
Developed countries	15	4
South-East Europe and CIS	5	4
Developing countries		
Africa	9	13
Latin American and the Caribbean	2	16
Asia and Oceania	15	1

Source: United Nations Conference on Trade and Development (UNCTAD), *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D*, Geneva, 2005. United Nations publication, Sales No. E.05.II.D.10.

* UNCTAD classification. CIS: Commonwealth of Independent States (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russian Federation, Tajikistan, Turkmenistan and Ukraine).

As mentioned, facilitation of R&D investment requires certain basic conditions to be met. It calls for stability and an investment-friendly business environment, infrastructure endowment (especially as regards information and telecommunications), protection of intellectual property and so on. By far the main pull factor, however, is the availability of adequate numbers of knowledgeable researchers at an attractive cost. Such human resources are usually to be found in an innovation-friendly environment, as reflected in the existence of an advanced national innovation system (NIS). UNCTAD (2005b) has developed an “innovation capability” index, built on two indicators: one measuring technological activity (which takes number of research staff, patents granted and scientific publications as proxies, all deflated by the number of inhabitants); and the other measuring human capital (whose proxies are the literacy rate and enrolment in secondary and tertiary education). The innovation capability index gives an indication of a country's capacity to attract FDI in R&D. The following table (Table 3) shows the indices of the countries examined. Countries that UNCTAD ranks as having a medium innovation capability are shown in bold typeface. Only four of the countries covered in this study (Chile, Costa Rica, Panama and Paraguay) explicitly identified investment in R&D or in highly complex

technology as a particular investment target. The first two countries would be in a position to rise to the challenge, but Paraguay would be well advised to redefine its strategic focus. The UNCTAD report did not furnish information on Panama. It is no simple undertaking to promote investment in R&D, and not all the countries have the advantages they would need to do so successfully. Nevertheless, transnational enterprises are increasingly inclined to make their R&D investments abroad. The countries of the region should at least be abreast of this trend and, where possible, try to capitalize on the opportunities arising in this area.

Summing up, we would like to finish this overview of FDI in Latin America and the Caribbean citing one of the conclusions founded it in the very recent Report of the Expert Meeting on the Impact of FDI on Development held at the Palais des Nations, Geneva (2005):

“In Latin America and the Caribbean, R&D activities of TNCs are very limited, especially when compared to Asia. One of the reasons for this is that in most Latin American and Caribbean countries, FDI policies focus on attracting large quantities of FDI and do not pay much attention to the nature of FDI. R&D-related FDI in the region is of an adaptive type, with some degree of new product development for local or regional conditions”.

Table (iii)

Selected countries: UNCTAD innovation capability index, 2001

	Innovation capability		Technological activity			
	Position	Index	Position	Index	Position	Index
Sweden	1	0.979	1	0.976	2	0.982
Japan	11	0.885	5	0.935	21	0.835
Ireland	21	0.814	22	0.781	18	0.848
Hungary	32	0.725	28	0.692	35	0.758
Czech Republic	36	0.690	30	0.680	38	0.701
Argentina	37	0.685	37	0.603	33	0.767
Chile	42	0.576	47	0.544	47	0.609
Brazil	49	0.529	52	0.478	52	0.579
Uruguay	52	0.506	71	0.298	37	0.715
Costa Rica	58	0.472	49	0.526	71	0.419
Mexico	59	0.469	54	0.461	65	0.477
Venezuela	62	0.460	56	0.468	64	0.482
Peru	63	0.425	74	0.289	57	0.561
Jamaica	67	0.395	68	0.315	67	0.475
Colombia	68	0.393	70	0.311	66	0.476
Ecuador	78	0.319	83	0.235	74	0.404
El Salvador	84	0.279	88	0.204	82	0.354
Paraguay	93	0.213	106	0.075	83	0.351
Guatemala	101	0.135	109	0.055	96	0.215
Angola	107	0.019	117	0.000	118	0.025
(last)						

Source: Economic Commission for Latin America and the Caribbean (ECLAC), on the basis of United Nations Conference on Trade and Development (UNCTAD), *World Investment Report 2005: Transnational Corporations and the Internationalization of R&D*, Geneva, 2005. United Nations publication, Sales No. E.05.II.D.10.

In this context, we explore in these essays another host-economy macroeconomic consequence of FDI, which has been poorly documented and quantified in the literature.⁴ Specifically, we are concerned with the distributive impact of FDI on raising wage inequality in developing countries. This issue is receiving remarkable attention from the part of the most important international agencies. The following quotation extracted from the very recent World Social Situation Report (2005) edited by the United Nations is fully pertinent at this point:

⁴ As anticipated, both the impact of FDI on national welfare and the generation of positive spillovers in host economies by FDI have widely focused the attention of researchers in this area.

“The process of economic liberalization is typically marked by greater wage flexibility and the erosion of minimum wages, a reduction in public sector employment, declining employment protection, and the weakening of employment laws and regulations. The desire of developing countries to attract foreign investment and expand exports frequently leads to a “race to the bottom” with labor protection and environmental standards often ignored or compromised, ostensibly to make the countries more competitive in the international market. External competitive pressures therefore restrict the ability of developing countries to pursue key aspects of social policy”.

To deal with this problem, we propose an original model that accounts for some of the empirical findings outlined in the literature and accounts of significant and unexplored causal mechanisms. From a policy perspective, because macroeconomic performance and policies are closely connected, a modest policy message to come out of our work is that, even in a pro-gradual-liberalization scenario, FDI may become a significant source of host-wage inequality if it is not accompanied by conscious local policies enhancing pro-technology adoption environments.

Our work is based on three original papers presented in separated chapters. The first two chapters deal with the aid-growth problem and the last one deals with the connection between foreign direct investment and host wage-inequality. Following is the description of each chapter.

Chapter 1

Foreign aid continues to be an important source of funds to poor countries. The popular claim on this issue says that its effectiveness on economic growth has been almost nil because aid is mostly channeled into consumption and not investment. Unfortunately, development literature has not offered so far a crystal strategy to study the problem of the allocation of aid across sectors. In this paper we argue that *two-sector* growth models à la Benhabib and Farmer (1996) involving foreign aid as an input in the

production functions are the natural frameworks to tackle this concern. We characterize the optimal resources allocation across sectors. Contrary to the popular claim, we clearly show that optimal allocation of aid does call for some allocation of aid directly into production of consumption goods. Furthermore, the model predicts that aid may have a positive effect on both long run investment and growth. In addition, it also suggests that long run variations in output are equally driven by both sectors. Once calibrated for countries like Bolivia and Zimbabwe, the simulations imply that the optimal long run impact of aid on economic growth may be delayed depending on the value of the relative price of the economy. More precisely, we demonstrate that, under perfect foresight scenarios, the higher is the relative price of the economy the slower is the impact of foreign aid on economic growth and more aid is needed to achieve rapid growth

Chapter 2

This chapter contains non-minor innovations to the model proposed in Chapter 1. Using an optimal discrete two-sector growth model involving consumption and investment, foreign aid is also introduced here as an intermediate good. However, the engagement of aid in production has two instants: (1) a fraction of it is endogenously and immediately allocated to consumption and investment; (2) the remaining units of aid go to households as infrastructure, plant buildings (and so on) therefore increasing their capital stock. Hence, this part of aid is put in production in *subsequent* periods of time. In other words, a part of aid plays a lagged role in production. The allocation of aid across sectors is also endogenously determined. Preferences obey, on the one hand, to the usual consumption-leisure structure. On the other hand, they also include aid reflecting the assumption that the planner also views this resource as a means of giving felicity to people. Leisure is endogenously allocated across sectors. The numerical exercises show that most of aid should be lagged in the long run, i.e., it

should be going firstly to increase people's capital stock and then put it in production. Besides, they also show that, in the long run, aid should be mostly consumed than invested, which is a salient fact of reality. On the other hand, dynamic simulations show a significant tradeoff between the impact of foreign aid on consumer welfare between the short and the long run. Particularly, it would not be optimal that the endogeneity of labor-leisure choice play a crucial long run role in the propagation of foreign aid shocks in terms of affecting resource allocation decisions -as it is claimed by Chatterjee and Turnovsky (2006).

Chapter 3

In this paper we study the host-economy's distributive consequences of foreign direct investment (*FDI*) on rising wage inequality in developing countries. By adopting a simple two-sector optimal growth model where a pro-gradual liberalization scenario is assumed à la Desmet and Rojas (2008), it is demonstrated that the technological gap vanishes asymptotically and that *FDI* can move freely in the economy depending on the spread between the local and the international interest rates. It is also shown that transitory external shocks promoting *FDI* inflows (a diminishing in the world interest rate, for instance) induce some improvements in the economy, particularly by reducing the technological gap. Moreover the level of wage inequality is increased and most importantly, serious short run consequences for the economy in terms of social welfare maximization appear in the very short run under constrained regime. Consequently, it is found that the better endowed the economy is, the higher *FDI* inflows are needed and the higher social welfare is lost. Robustness tests confirm the above results.

Chapter 1

Foreign Aid: Optimal allocation and the role of the relative price

1.1 Introduction

Much time has passed since foreign aid programs were launched massively in the 1960s and, in the words of Krugman (2002), “Latin America is too far from the rose garden that developed countries promised it. On the contrary, too many people there got nothing but thorns”. Unfortunately, having a look at the evidence across the world, these words can also be extended to the rest of the globe, particularly to the African continent. Therefore, it seems clear that economic research on foreign aid and growth is clearly an attention-worthy topic due to the huge amount of funds that mainly international institutions, such as the World Bank and the IMF, move each year in order to help developing countries—and so far without much success. Following are some issues related to this problem.

In reality, it is well known that for nearly fifty years, many poor and developing countries (PDCs) that have been facing the combination of severe balance of payment problems, high and variable inflation, slow growth, and high unemployment, have steadily viewed and invoked foreign aid as a crucial ingredient in their development strategy. As a result, almost

all PDCs have entered into agreement for multilateral financial support with some international financial institution (IFI) like the World Bank and the IMF at least once since 1970.⁵ Similarly, bilateral financial agreements between most poor countries and different donors constitute a significant item in the agenda of the North-South relationship. As a consequence, these countries have been undertaking heavy structural adjustment programs in their economies, in many cases facing sharp crises.⁶

On the academic side, most researchers using empirical models have found that aid has mostly gone to “consumption” rather than to investment. In addition, when positive long-run variations in output have been observed these have been mostly driven *by* consumption. Lastly, aid has not significantly increased investment, neither in the long- nor the short-run.⁷

However, in the words of Easterly (2003), *“the empirical literature on the connection between aid and economic growth has been hampered by the lack of a clear theoretical model by which aid would influence growth and which could pin down the empirical specification of the aid-growth relationship. Moreover, aid agencies have been applying models that have supposedly been dead since long ago in order to calculate short-term investment requirements for a target growth rate”*⁸.

In this context, it is hardly surprising that since the 1990s the debate has been concentrated much more on qualitative aspects of this puzzle. Accordingly, the famous ‘good’ policies à la Burnside and Dollar (2000) have become almost universally accepted as *the* reference points considered by donors and International Financial Institutions like the World Bank and the IMF providing aid and, more importantly, as guidelines to be followed by

⁵ See Barro and Lee (2005).

⁶ Corbo and Fischer (1995) offer a starting point for this theme.

⁷ See, for example, Boone (1996), Easterly (1999), Przeworski and Vreeland (2000), among many others. A positive association between aid and investment for the case of Pakistan is found in McGillivray’s (2000) study.

⁸ See Easterly (1999).

recipients needing this aid.⁹ Nevertheless, as is cogently pointed out by Przeworski and Vreeland (2000), Easterly (2003), and more recently by Clemens, Kenny and Mass (2004) and Rajan and Subramanian (2005), there is a lack of serious economic robustness analyses supporting either the choice of these policies or the Burnside and Dollar's findings.

In summary, the available evidence seems to be quite convincing to show that the main goals that the boards of the IFIs and donors have claimed for decades, namely, to alleviate poverty and spur growth through foreign aid are far from being achieved. The popular claim on that is that aid does not work in practice because it is more "consumed" than invested and evidence seems to confirm this issue. However, people (donors and IFIs) are concerned about because there is the *presumption* that, for various reasons (e.g. corruption or governments vote buying), aid is not *optimally* allocated. In short, the reasons underlying this poor performance are still in question among economists. In other words, our knowledge about aid effectiveness and economic growth is far from being complete, particularly from the macroeconomic perspective.

In this chapter we present the baselines of a new quantitative framework to deal with this problem. Our main point is that a comprehensive analysis of the macroeconomic impact of aid should take into account the sectoral composition of the economy. Indeed, the standard way to formally tackle this kind of problem has been by using one-sector models in which aid is taken as an exogenous lump-sum transfer variable¹⁰. The main disadvantage of these (scarce) models is that they do not give a *formal* response to what should be, in our view, the first question to be posed on this matter: how the money coming from foreign aid should be spent by recipient countries? This has given rise to a long-standing debate, both in academic and policy circles, as to whether international transfers should be "tied" ("productive") or "untied" ("pure"). As Bhagwati (1967) points out, tied external assistance can take several forms. It may be linked to: (1) a specific

⁹ Broadly speaking, it refers to policies tending to liberalize the economy most of which are contained in the controversial "The Washington Consensus Statement".

¹⁰ See Obstfeld (1999).

investment project, (2) a specific commodity or service, or (3) procurement in a specific country. Recent studies by the World Bank point out that over time, a larger proportion of foreign aid has become “untied” with respect to requirements for procuring goods and services from the donor country, but it has become more “tied” in the sense of being linked to investments in public infrastructure projects (telecommunications, energy, transport, water services, etc). Between 1994 and 1999, for example, the proportion of aid that was “untied” in the sense of not being subject to restrictions by donors on procurement sources rose from 66 percent to about 84 percent. At the same time, between two-thirds and three-fourths of aid was either fully or partially tied to public infrastructure projects¹¹.

Close to the spirit of Benhabib and Farmer (1996), we follow here a different approach to answer the question above more properly. We propose a simple optimal forward-looking two-sector growth model involving capital stock as the primary factor of production of consumption and investment goods. In addition, this time following the spirit of Barro (1990), we assume that production also requires the provision of public services which, for the purposes of the paper, are provided entirely from foreign aid. Even though aid is a source of funds that can be allocated to different uses, we think the way aid is introduced into our model is appropriate because it captures the main goal of our research, namely, to know more accurately which would be the optimal allocation of aid across sectors. Although our main objective is clearly narrow, we do think that this is a first and necessary step in order to better understand the theoretical grounds linking aid and economic growth which have been poorly studied.

In terms of results, our model suggests, by construction, that it is optimal that aid is mainly “consumed” and not saved. Moreover, the model predicts that permanent aid inflows should have a positive effect on all the aggregates in the long-term. More specifically, it puts in evidence the existence of positive long-run variations in output which are equally driven by consumption and investment in the long run.

¹¹ See World Bank (1994, 2004)

In addition, it is formally verified that, in the long-term, the marginal productivity of aid in consumption is greater than the marginal productivity of aid in investment for countries where at least 50 percent of aid is used in consumption. We do think that this result is important not only to understand the incentives (or mechanisms) behind aid allocation but also because this property has just been conjectured by previous authors¹².

The model is then calibrated for *ad hoc* countries like Bolivia and Zimbabwe using 1970-1993 time-series data. The simulations show, on the one hand, that it is optimal to reallocate resources in favor on investment during a significant part of the total period under aid acceleration. On the other hand, they also show that as the magnitude as the timing of this reallocation will strongly depend on the marginal rate of transformation of consumption into capital goods, which is identified here from the relative investment price data. More specifically, we show that a planner ruling an economy where the relative price of investment goods is bigger than one is forced to smooth the growth rate of the economy therefore prolonging the period at which it will absorb totally the shock on aid.

The remainder of this paper is organized as follows. Section 1.2 specifies the structure of the model. Two calibrated examples are offered in Section 1.3, while Section 1.4 deals with the dynamics of the model. Section 1.5 concludes.

1.2 The Model

1.2.1 The basic structure

Following Benhabib and Farmer (1996), we assume here an optimal two-sector time-discrete economy producing at time investment goods (I_t) and consumption goods (C_t). To produce these goods, capital K_t is needed as the primary factor of production. A fraction of $\mu_{K,t}$ units of this capital is used

¹² See Easterly (1999).

in the consumption goods industry and the remaining units $(1-\mu_{K,t})$ are used in the investment one.

In addition, and in the spirit of the seminal work by Barro (1990), we assume that production also requires the provision of exogenous public services F_t which, for the purposes of the paper, are provided entirely from *foreign aid*. For concreteness, we can think of aid not only as “law and order” services — like Alesina and Rodrik (1994) — but also as foreign technical and medical assistance, specific investment projects, and so on. For simplicity, aid inflows are assumed to be costless. Though many types of aid involve substantial costs for recipient countries, others do not. Moreover, certain types of it are even free or they have been forgiven by donors! Further, we assume that $\mu_{F,t}$ units of this aid are endogenously allocated to the consumption sector and the remaining units $(1-\mu_{F,t})$ are allocated to investment. Hence, by assuming constant returns-to-scale in both technologies, we adopt a modified version of the formulation provided by Barro (1990) and Barro and Sala-i-Martin (1995) to yield the aggregate production functions:

$$C_t = A_t \cdot (\mu_{K,t} K_t)^\alpha (\mu_{F,t} F_t)^{1-\alpha} \quad (1)$$

$$I_t = B_t \cdot [(1-\mu_{K,t}) K_t]^\alpha [(1-\mu_{F,t}) F_t]^{1-\alpha} \quad (2)$$

In these equations, A and B are the usual TFP (total factor productivity) parameters; $0 < \alpha < 1$ is the capital share; $0 \leq \mu_{F,t} \leq 1$ is the share of aid in consumption and F is the level of aid, which is assumed exogenously determined and strictly positive¹³. In short, equation (1)-(2) put in evidence the key assumption on aid as forming part in production (tied

¹³ This condition means that aid is viewed as permanent income by aid-recipient countries. According to Easterly (1999), “...there is considerable justification for viewing it as such given its persistence...”. Obstfeld (1999) makes the same assumption.

aid), which is fully in opposition to the standard treatment which considers aid as a lump-sum transfer¹⁴.

Notice that the two industries use identical technology with the exception of the two scaling factors A and B ¹⁵. Finally, we assume that capital stock is depreciated at a constant level of δ in one period so that the law of motion of capital has the standard structure

$$K_{t+1} = (1-\delta)K_t + I_t \quad (3)$$

where I_t denotes gross investment in physical capital measured in units of capital.

1.2.2 The central planner problem

We consider the following optimal growth problem:

$$\underset{\{\mu_{F,t}, \mu_{K,t}, I_t, K_{t+1}, C_t\}}{\text{Max}} \sum_{t=0}^{\infty} \beta^t U(C_t) \quad (\text{P1})$$

This subject to equations (1) to (3); $K_0 > 0$ given, and the corresponding positive constraints (particularly $0 < \mu_{F,t}, \mu_{K,t} < 1$ and $0 < \alpha < 1$). $U(\cdot)$ is a standard utility function and $\beta < 1$ is the usual time discounting factor. By means of successive substitutions, one can reduce the system of three restriction equations (1) to (3) so that the corresponding Lagrangian is read as¹⁶

$$\begin{aligned} \max_{\{\mu_{K,t}, \mu_{F,t}, K_{t+1}\}_{t=0}^{t=\infty}} L = & \sum_{t=0}^{\infty} \beta^t U(C_t) \\ & + \sum_{t=0}^{\infty} \beta^t \lambda_t \left\{ (1-\delta)K_t + B_t \cdot [(1-\mu_{K,t})K_t]^\alpha [(1-\mu_{F,t})F_t]^{1-\alpha} - K_{t+1} \right\} \end{aligned}$$

¹⁴ See, for example, Obstfeld (1999).

¹⁵ Our results are virtually unchanged under different technologies.

¹⁶ In this expression, we have reduced the initial number of control variables by substituting equation (2) into (3).

The interior solution for this optimization problem is characterized by the following first order conditions:

$$\frac{(1-\mu_{K,t}) \cdot U'(C_t) \cdot C_t}{\mu_{K,t}} = \lambda_t I_t \quad (4)$$

$$\frac{(1-\mu_{F,t}) \cdot U'(C_t) \cdot C_t}{\mu_{F,t}} = \lambda_t I_t \quad (5)$$

$$\lambda_t - \beta \lambda_{t+1} \left[(1-\delta) + \frac{\alpha I_{t+1}}{K_{t+1}} \right] = \frac{\beta \alpha U'(C_t) \cdot C_t}{K_{t+1}} \quad (6)$$

In this set of equations, λ is the multiplier associated with the law of motion of capital (3). Equations (4)-(5) are the optimality conditions with respect to the allocation variables μ_K and μ_F , respectively. Equation (6) provides the optimal intertemporal rule for K_{t+1} .

Having a look at equations (4) and (5), it is easily verifiable that

$$\mu_{K,t} = \mu_{F,t} \equiv \mu_t \quad (7)$$

In words, equation (7) means that the allocations of capital and aid are the same across sectors, i.e., same proportions of them are assigned to consumption (or investment) at each period of time.

Consequently, equations (1)-(2) can be rewritten as follows:

$$C_t = A_t \mu_t K_t^\alpha F_t^{1-\alpha} \quad (8)$$

$$I_t = B_t (1-\mu_t) K_t^\alpha F_t^{1-\alpha} \quad (9)$$

Then, like Benhabib and Farmer (1996), the output of the economy can also be defined as

$$Y_t \equiv C_t + (A/B) I_t = C_t + p_t I_t = A_t K_t^\alpha F_t^{1-\alpha} \quad (10)$$

where $p_t = A/B$ represents the marginal rate of transformation of consumption into capital goods (henceforth, *MRT*). Countries with lower p_t are more efficient at producing investment goods, requiring a lower sacrifice in terms of consumption and, in turn, in terms of welfare in order to produce one unit of capital. Using this definition, we note that the level of F does not affect this rate. We shall see later that this property will allow us to understand (partially) the role of this variable in allocating aid across sectors, particularly in the short run.

Recalling now that the main purpose of the paper is to know how foreign aid is allocated across sectors, it is easily followed from equations (7), (8) and (10) that the aid allocation in consumption equals the consumption-to-output ratio, i.e.,

$$\mu_{F,t} = \frac{C_t}{Y_t} \quad (13)$$

Therefore, the model suggests—by construction— that it is optimal that aid inflows be mostly allocated to the consumption good sector at each point in time.

We now turn to the analysis of the steady state properties of the dynamics system.

1.2.3 The steady state paths: existence and comparative static

From now, we assume a logarithmic utility function. Equations (3) and (6) to (10) define a set of six equations for six unknowns $(\hat{\mu}, \hat{K}, \hat{C}, \hat{I}, \hat{Y}, \hat{\lambda})$. Fortunately, it is possible to reach analytically the steady state value in terms of the parameters and the exogenous variables of the model. By getting rid of now the multiplier, it is quite simple to prove after simple algebra that the long-term levels are determined by the following restrictions¹⁷:

¹⁷ We can use indistinguishable equation (4) or (5) to get rid of the multiplier λ .

Proposition 1. *If $\beta[(1-\delta)+\delta\alpha] < 1$, there is a unique positive steady state characterized by the following values of the endogenous variables:*

$$\hat{\mu} = \frac{1 - \beta[(1-\delta) + \delta\alpha]}{1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha} \quad (14)$$

$$\hat{K} = \left[\frac{B\beta\delta\alpha}{\delta[1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha]} \right]^{\frac{1}{1-\alpha}} \cdot F \quad (15)$$

$$\hat{C} = A \cdot \left[\frac{1 - \beta[(1-\delta) - \delta\alpha]}{1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha} \right] \cdot \left[\frac{B\beta\delta\alpha}{\delta[1 - \beta[(1-\delta) - \delta\alpha] + \beta\delta\alpha]} \right]^{\frac{\alpha}{1-\alpha}} \cdot F \quad (16)$$

$$\hat{I} = \delta \cdot \left[\frac{B\beta\delta\alpha}{\delta[1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha]} \right]^{\frac{1}{1-\alpha}} \cdot F \quad (17)$$

$$\hat{Y} = A \cdot \left[\frac{B\beta\delta\alpha}{\delta[1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha]} \right]^{\frac{\alpha}{1-\alpha}} \cdot F \quad (18)$$

Proof: To prove the existence of the steady-state is very simple and it does not require more details. In terms of unicity, it is easy to realize that once the set of parameters and the exogenous variables are specified each one of the endogenous variables is univocally determined. Besides, by defining

$$x = 1 - \beta[(1-\delta) + \delta\alpha], \text{ it is clear that } \hat{\mu} = \frac{x}{x+a} < 1 \text{ since } a = \beta\alpha\delta > 0 \quad \blacklozenge$$

Two points are worth highlighting here. First, we observe from equation (14) that the long-run level of aid allocation in consumption (and in turn in investment) does not depend on any exogenous variable, particularly on the level of aid F . In fact, we see that it is just a function of the parameters of the economy. In words, the model suggests that the amount of aid would play no role in the planner's decision allocating aid across sectors in the long-term. We think that this long run result is important

because it is suggesting that recipient countries should revise their structural parameters in order to optimize the allocation of their available resources. This would help these countries to turn them less dependent on an exogenous variable like aid. The popular claim on that is that this is something expected to occur in developing countries!

Second, equations (15) to (18) show that aggregates such as capital, consumption, investment and output are all of them F -linear-dependent. Consequently, the optimal long run response to any increase (shock) in the level of aid should be followed by a fully and equally absorption of the shock by both technologies. This means that an increase in F in $x\%$ goes up both consumption and investment in $x\%$ ¹⁸. From Proposition 1, the following comparative static with respect to F can be easily proved:

Proposition 2: Being $MPAC$ ($MPAI$) the marginal productivity of aid in consumption (investment) in the long run, we have the following comparative static properties¹⁹:

$$MPAC = \frac{\partial \hat{C}}{\partial F} \Big|_{c,p} = A \cdot \underbrace{\left[\frac{1 - \beta[(1-\delta) + \delta\alpha]}{1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha} \right]}_{\hat{\mu}} \cdot \left[\frac{B\beta\delta\alpha}{\delta[1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha]} \right]^{\frac{\alpha}{1-\alpha}} \quad (19)$$

$$MPAI = p \cdot \frac{\partial \hat{I}}{\partial F} \Big|_{c,p} = A \cdot \left[1 - \underbrace{\frac{1 - \beta[(1-\delta) + \delta\alpha]}{1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha}}_{\hat{\mu}} \right] \cdot \left[\frac{B\beta\delta\alpha}{\delta[1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha]} \right]^{\frac{\alpha}{1-\alpha}} \quad (20)$$

$$MPAC|_{s,s} > MPAI|_{s,s} \quad \text{if} \quad \hat{\mu} = \frac{1 - \beta[(1-\delta) + \delta\alpha]}{1 - \beta[(1-\delta) + \delta\alpha] + \beta\delta\alpha} > 0.5 \quad (21)$$

As anticipated, equations (19) and (20) show that neither the long run marginal productivity of aid in consumption nor in investment depend on the

¹⁸ However, empirical studies argue that long-run variations in output caused by aid inflows are driven by consumption and not by investment.

¹⁹ Notice that the marginal productivity of aid in investment is multiplied by p in order to compare with the marginal productivity of aid in consumption correctly.

exogenous level of aid F , but on the total factor productivities A and B and the structural parameters of the economy. In addition, we observe that any shock in these technical variables equally impacts the value of both marginal productivities. In other words, if the planner tries (for any reason) to make changes on these marginal productivities in favor of one particular sector, the model suggests that the sole way to do it is by altering the structural parameters determining the value of $\hat{\mu}$, namely, the rate of depreciation, the time discount factor and the capital share. As a consequence, we note that the marginal rate of transformation of consumption into investment goods does not affect the allocation of resources across sectors in the long run. In addition, it is clear that the $MPAC$ will be bigger than the $MPAI$ for all $\hat{\mu} > 0.5$. Particularly, if the planner fits the parameters in such a way that at least 50 percent of aid is used in consumption, this sector will receive more aid inflows in the long-run.

1.3 Dynamics

From Propositions 1 and 2, we have observed that the long run behavior of the economy seems to be quite predictable under changes in the level of aid F . Now, we study how this variable affects the transition dynamics to the steady state growth paths, particularly when the MRT of economy is lower or bigger than one²⁰. By doing this, we shall see this latter variable plays a role in allocating resources in the short run under aid acceleration. To this end, we resort to numerical experiments. The dynamics system is reported in Appendix A. We simulate two calibrated versions of this system²¹ which differ each other mainly in the value of the MRT . We follow the same assumption made by Castro (2005) which identifies this variable directly from the relative investment price data. In other words, the MRT is calibrated

²⁰ If the relative price is bigger than one means the economy must “sacrifice” more than one consumption good to produce one investment good.

²¹ We use Dynare, the package developed by Juilliard (2002), for the simulations and stability assessment of nonlinear forward-looking variables.

here as representing the economy's relative price of investment goods²². We have chosen two *ad hoc* countries just to show to what extent this variable may affect economic growth under changes in the level of aid.

Accordingly, we first calibrate the model to fit some broad stylized facts about the Bolivian economy during the period 1970-1995. Then, we make the same for the Zimbabwean economy. We have chosen this period of time in order to make figures comparable (in time) with Burnside and Dollar (2000)'s database on foreign aid which covers data on this variable from 1970 to 1995. Furthermore, Bolivia has received significant debt reliefs from the Multilateral Debt Relief Initiative during the last decade qualifying even for possible debt forgiveness in the near future²³. On the other hand, Zimbabwe has not paid for aid services for a long time. The country is still trying to convince IMF's officers and donors to be included in the list of countries waiting for debt forgiveness²⁴. These two issues give support to the assumption that aid is costless in this mode.

According to the World Development Indicators Database 2010, Bolivia's GDP reached \$1,208 millions in 1970 (in 2007 US dollars) and \$6,715 million in 1995. In terms of GDP per capita, this meant an amount of \$286.92 for 1970 versus \$897.55 for 1995²⁵. On the other hand, the ratios consumption to GDP and foreign aid to GDP reached (on average), respectively, 0.67 and 0.018²⁶. Finally, the empirical evidence available shows for Bolivia the figure for the relative price of investment goods (in terms of consumption goods) of 0.75 and of 1.96 for the ratio capital to output²⁷.

²² At this point, it is worth emphasizing the fact that our paper merely underscores the importance of understanding why relative investment prices differ across countries, which is an important issue in development economics. See more details in Section 1.4.

²³ See <http://www.imf.org/external/np/exr/facts/mdri.htm>

²⁴ <http://www.voanews.com/zimbabwe/news/Zimbabweans-Should-Not-Expect-IMF-Debt-Forgiveness-105886018.html>

²⁵ All figures in 2007 US dollars.

²⁶ See Burnside and Dollar (2000)'s database and Penn Tables 6.0.

²⁷ See Castro (2005). We thank to Rui Castro for kindly providing me with his data base.

We now present the results of the calibration procedure in Table 1.1.

Table 1.1: First parameterization: Bolivia

Parameter	Symbol	Value
Time discounting factor	β	0.98
Rate of depreciation of capital	δ	0.16
Capital share	α	0.37
Total factor productivity in consumption	A	8.78
Total factor productivity in investment	B	11.7
Level of aid	F	1

The parameter α , the capital share, β , the time discounting rate have been fixed to some usual values²⁸. The depreciation rate of capital, δ , has been fixed so as to have a ratio capital to GDP (in terms of consumption goods), i.e., pK/Y , equal to 1.96. For a fixed value of F (the level of aid), the total factor productivity in the consumption sector A and in the investment sector B are such that the share of aid in GDP is 1.80% and the relative price of investment goods is 0.75²⁹. Table 1.2 shows the long run properties of this parameterization.

Table 1.2: Long run implications of the calibration: Bolivia

Endogenous variable	Symbol	Value
Share of aid in consumption	$\hat{\mu}$	0.67
Ratios		
Consumption to GDP	C/Y	0.67
Capital to GDP	pK/Y	1.96
Aid to GDP	F/Y	0.0180
Relative price	p	0.75

²⁸ See, for example, Boucekkine *et al.* (2006).

²⁹ For more details, see Appendix C, Table A.

As mentioned, the second calibration of our model fits some broad stylized facts about the economy of Zimbabwe during the period 1970-1995. According to the World Development Indicators Database 2010, Zimbabwe's GDP reached \$1,884 millions in 1970 and \$7,111 millions in 1995. In terms of GDP per capita, this meant an amount of \$361.26 for 1970 versus \$601.65 for 1995; all figures in 2007 US dollars. The ratios consumption to GDP and foreign aid to GDP reached (on average) 0.69 and 2.34%³⁰, respectively. According to Castro (2005), the values of the relative price of investment goods (in terms of consumption goods) and the ratio capital to output have been estimated by 1.33 and 1.76, respectively. Using the same calibration procedure used for Bolivia, the results of this process are presented in Table 1.3 and its long run properties are listed in Table 1.4:

Table 1.3: Second calibration: Zimbabwe

Parameter	Symbol	Value
Time discounting factor	β	0.98
Rate of depreciation of capital	δ	0.18
Capital share	α	0.35
Total factor productivity in consumption	A	10.4
Total factor productivity in investment	B	7.84
Level of aid	F	1
Relative price	p	1.326

Table 1.4: Long run implications of the calibration: Zimbabwe

Endogenous variable	Symbol	Value
Share of aid in consumption	$\hat{\mu}$	0.69
Ratios		
Consumption to GDP	C/Y	0.69
Capital to GDP	pK/Y	1.76
Aid to GDP	F/Y	0.0234

³⁰ See Burnside and Dollar (2000)'s database and Penn Tables 6.0.

Notice that the main difference between the two calibrations lies in the value of the relative price: $p > 1$ for Bolivia and $p > 1$ for Zimbabwe.

Recalling that the main objective of this paper is to investigate how aid inflows should be allocated across sectors, we see from tables 1.2 and 1.4 that aid is mostly used in consumption which confirms the predictions made in Section 1.2.2. Besides, given the share of aid (and capital) in consumption is higher than 0.5 in both cases, the marginal productivity of aid in this sector ($MPAC$) is bigger than the marginal productivity of it in investment ($MPAI$), as stated in Proposition 2. In short, the model suggests that it is optimal that foreign aid, viewed as an intermediate good in production, enhances mostly the production of consumption goods in the long run.

We now turn to the short term dynamics. We consider a permanent and unexpected shock in the level of aid F affecting the economy from $t = 0$. The dynamic simulations are conducted on the calibrated model described in Section 1.2.3. The magnitude of the shock is set to 1%. The solution paths are displayed in Figure 1 for Bolivia and Figure 2 for Zimbabwe. Each solution path represents the evolution of **the percentage deviation** across time of a given variable respect to the initial steady state value. This evolution is measured in the vertical axe. The horizontal axe measures periods. Since the share of aid in consumption (investment) is equal to the share of capital in consumption (investment) at any time, we have plotted in Figure 1 and Figure 2 just one of them in order to unburden the presentation.

1.3.1 Optimal allocation under aid acceleration

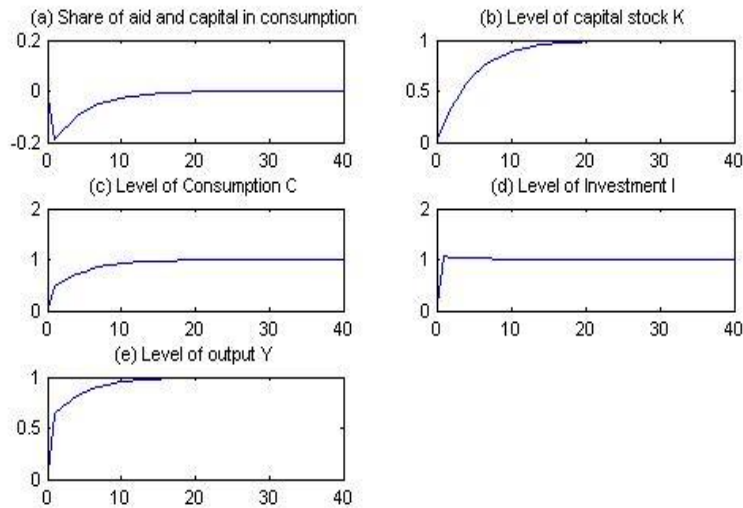
Let us now analyze how this economy reacts to the shock. The main finding to be highlighted from the simulation is:

- (i) When the economy of Bolivia benefits from new aid inflows, we observe a clear reassignment of resources in favor of investment lasting around 20

periods (the middle of the total period). This is shown by the fall in the share of aid (and capital) in consumption³¹. See Figure 1(a). Consequently, investment is observed to rise more than consumption during a significant part of the total period. See Figures 1 (c)-(d). The issue now is to understand this behavior. There a simple reason for this. A central planner ruling an economy under rational expectations (perfect foresight) and in the absence of any adjustment costs will try to balance sectors as much as possible, particularly if the shock is permanent and if this balancing is compatible with social welfare maximization. This is actually a well-know property of this kind of models. .As a result, short-run positive variations observed in output are mainly driven by investment. In addition, as anticipated by Proposition 1, it is confirmed that as consumption as investment absorb totally the magnitude of the shock in the long-term and long-run variations in output are equally driven by both sectors of the economy. To state this in a different manner, the increase in F by 1% is followed by the increase in *both* industries by 1%. See Figures 1(c)-(d). As a final result, output is also increased by 1% in the long run. However, we note that this value is reached just in the middle of the total period which reflects a slow impact of aid on economic growth. See Figure 1(e).

³¹ As it was shown in equation (7), the values of the share of aid in consumption and the share of capital in consumption are both the same.

Figure 1: Percentages responses to an increase in the level of F in 1%³² (Bolivia)

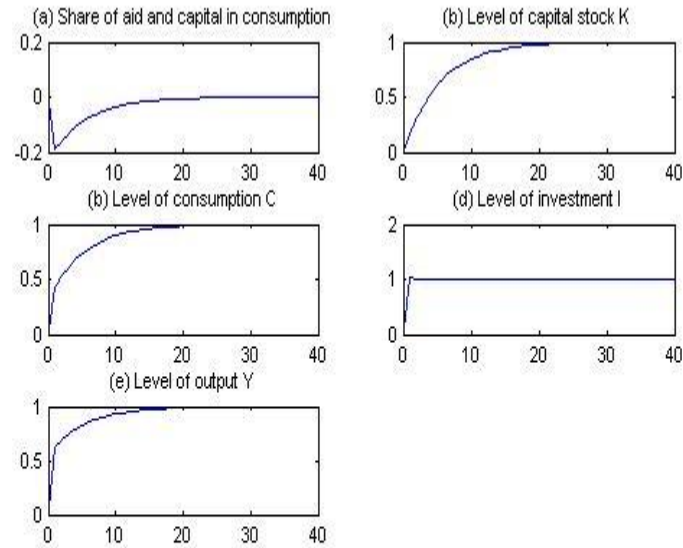


(ii) When the economy of Zimbabwe benefits from new aid inflows, we see the solution paths for all the variables follow basically the same lines observed in the case of Bolivia. There are however some quantitative differences. In fact, we observe that the reassignment of resources in favor of investment lasts more than 20 periods, i.e., it takes more time than in the previous exercise. See Figure 2(a). As a consequence, consumption and output absorb fully the shock a few periods later than those observed in the case of Bolivia therefore provoking that the long-term impact of foreign aid on output is still slower in this case. See Figure 2(e). This latter property comes from an important and potential arbitrage settlement in the model. Under perfect foresight, a central planner knows that the economy will experience an expansion in the long run due to the permanent shock on

³² We have omitted the word *period* below the horizontal axis to unburden the presentation.

foreign aid. From the previous excursive, we know that a planner who cares about consumption is willing to reallocate some resources in favor of investment in the short run because this option is compatible with social welfare maximization and because it allows him to balance sectors as much as possible. However, this property turns more complex ruling an economy where the relative price of investment goods is bigger than 1, which is just the case of Zimbabwe. Why? Just because more consumption goods are needed to produce one investment good, i.e., more social welfare maximization (compared to the case where the relative price is lower than 1) is needed to be “sacrificed” in order to correct sectoral imbalances. As a result, the planner is forced to smooth the growth rate of the economy therefore prolonging the period at which it will absorb totally the shock on aid (long-run situation). Put differently, the simulations suggest the higher the relative price of the economy more aid is needed to achieve rapid growth !

**Figure 2: Percentages responses to an increase in the level of F in
1%³³
(Zimbabwe)**



1.4 Results and Discussion

In this paper we have provided the baselines for a new theory of the macroeconomic impact of foreign aid in recipient countries, particularly poor ones. Unfortunately, few studies have explored the potential of quantitative theory to study this issue, even though the relevance of the subject. Our main point is that a comprehensive analysis of the macroeconomic impact of aid should take into account the *sectoral* composition of the economy. In other words, we do think that the previous one-sector models dealing with

³³ We have omitted the word *period* under the horizontal axis to unburden the presentation.

this problem are not sufficient to understand the theoretical grounds linking aid and economic growth. Certainly, the use of this kind of models strongly restricts our capacity to know more accurately how aid should be allocated by recipients. We claim that two-sector models à la Benhabib and Farmer (1996) and Fuentes (2004) involving aid as an intermediate input in production are the natural frameworks to tackle this problem more properly. At this point, we would like to insist on the issue that the way aid let in the economy is appropriate since it captures the main goal of this research, namely, to know more accurately where aid inflows should be allocated across sectors.

Our main result is that aid should be significantly more consumed than invested at any time. In addition, analyses conducted on the long run behavior of the economy suggest that the allocation of resources across sectors should not depend on the amount of aid but on certain key structural parameters of the economy. We do think that this is an interesting outcome of the model because it suggests that it would be optimal that amount of aid play no role in the decision-making process of allocating inputs in the long run, which would give incentives to revise structural (or internal) parameters of the economy in order to reassign inputs in favor of a specific sector; particularly the investment one if “good” long run-growth is expected to be achieved³⁴. Specifically, our model suggests that reductions in the rate of depreciation (by capital maintenance, for example) or increments in the capital share would benefit the reassignment of resources to investment³⁵.

³⁴ According to Chatterjee and Turnovsky (2006), “the move toward *productive* more aid to public investment has been dictated mainly by the growing infrastructure requirements of developing countries. Most economists agree that investment in public infrastructure raises the productivity and efficiency of the private sector and, as a consequence, provides a crucial channel for economic growth, development, and higher living standards. Input allocation to investment is favored by reductions in the rate of depreciation through capital maintenance and increments in the capital share.

³⁵ Boucekine, Martinez and Saglam (2001) suggests that maintenance of capital goods should be taken very seriously in the South since an increase in the maintenance effort ensures a rise in the income level in the long run.

This possibility would certainly help to reduce the recipient's long run dependence on aid, which is something expected to occur in the future.

On the other hand, it is formally verified that the marginal productivity of aid in consumption is greater than the marginal productivity of aid in investment for countries where at least 50 percent of aid is used in consumption in the long-term. This is an important result taking into account that the previous related literature has just offered conjectures on this particular point³⁶. Said in other words, we have clearly and formally identified the main mechanism transferring aid across sectors under changes in the amount of it in the long run.

Once calibrated for countries like Bolivia and Zimbabwe, the model implies that the optimal long run impact of aid on economic growth may be delayed depending on the value of the relative price of the economy, particularly when this variable is higher than 1. As a consequence, the simulations suggest that more aid would be needed to achieve rapid growth in such scenarios (high values of the relative price). At this point, the available evidence shows that most poor and developing countries look high values of the relative price of investment which can be viewed as a barrier to capital accumulation and development. If this variable may become so problematic in such cases, could aid then promote capital accumulation throughout reductions in the relative price of the economy in order to achieve rapid growth? Since the scope of our paper is very limited, we cannot answer this question properly with our model because we have shown that, by definition, the relative price of investment is just an exogenous variable not reflecting the broad range of economic policy and institutions (such as taxation, trade restrictions, obstacles to production, corruption, bureaucratic regulation, (among others) which affect its formation process over time and, more importantly, determine in a great part their differences across nations³⁷.

³⁶ See Easterly (1999).

³⁷ See Restuccia and Urrutia (2001) for more details.

1.5 Conclusion

Overall, the model predicts that aid should work in terms of achieving long run growth. Moreover, it suggests that as consumption as investment should equally drive this achievement. Both results are not so much observed in reality. In other words, these stylized facts, once evaluated with our optimal model, show sub-optimality. We have abstracted entirely from any political economy factors relating to rent-seeking, bad governance (or others) which are clearly relevant issues in any foreign aid discussion. However, we do believe that if we economist want to insist in finding a real link between foreign aid and economic growth, the right way to do it is by considering the sectoral composition of the recipient economy. We are still investigating how these (and the above) important issues can be introduced in our basic set-up in order to better understand whether aid can (or cannot) buy “good” growth

Chapter 2

Lagged Aid, flexible labor supply and Optimal Growth

2.1 Introduction

Official Development Assistance (hereafter “foreign aid” or “aid”) is an important mechanism by which wealth is transferred from rich nations to poorer economies. Huge and increasing amounts of money have been moved to help poor countries over the last four decades. For instance, total flows of aid from members of the OECD and OPEC countries have increased from about \$6 million in 1965 to over \$59 billion in 2002, stabilizing it in around \$50 billion a year between 2003 and 2008³⁸. According to the World Bank (2004), these funds had come to represent between 3-5 percent of the Gross National Income of the recipient low and middle income countries, and to finance between 10-20 percent of their gross capital formation. More recently, former President George W. Bush called for increasing U.S. *bilateral* development assistance by about 50 percent by fiscal year 2006, gradually raising aid above the current level of roughly \$10 billion. The new Millennium Challenge Account would direct the

³⁸ See Chatterjee and Turnovsky (2006),

additional funds to poor countries that have “sound” policy environments. Likewise, the World Bank is advocating a doubling of the current \$50 billion Official Development Assistance worldwide.

An important objective of much of this aid to developing countries is the promotion of economic development and welfare, usually measured by its impact on economic growth. Yet, after decades of enormous capital transfers to these countries, and several studies of the empirical relationship between aid and growth, the effectiveness of foreign aid in achieving these objectives remains questionable. This fact gives the general motivation of our research on this subject.

One significant issue of concern for both donors (and recipients) is how foreign aid should be spent in an economy with scarce resources. This worry has given rise to a long-standing debate, both in academic and policy circles, as to whether international transfers should be “tied” (“productive”) or “untied” (“pure”). As Bhagwati (1967) points out, tied external assistance can take several forms. It may be linked to: (1) a specific investment project, (2) a specific commodity or service, or (3) procurement in a specific country. Recent studies by the World Bank point out that over time, a larger proportion of foreign aid has become “untied” with respect to requirements for procuring goods and services from the donor country, but it has become more “tied” in the sense of being linked to investments in public infrastructure projects (telecommunications, energy, transport, water services, etc). Between 1994 and 1999, for example, the proportion of aid that was “untied” in the sense of not being subject to restrictions by donors on procurement sources rose from 66 percent to about 84 percent. At the same time, between two-thirds and three-fourths of aid was either fully or partially tied to public infrastructure projects³⁹.

According to Chatterjee and Turnovsky (2006), “the move toward tying more aid to public investment has been dictated mainly by the growing infrastructure requirements of developing countries. Most economists agree that investment in public infrastructure raises the productivity and efficiency of the private sector and, as a consequence, provides a crucial channel for

³⁹ World Bank (2004).

economic growth, development, and higher living standards. But financing public investment has proven to be a challenging task for developing economies. Most such countries have significantly restricted public borrowing after the debt-crisis of the early 1980s, while at the same time their infrastructure requirements have increased steadily. A 1994 World Bank study has estimated these requirements to be \$200 billion a year". Consequently, facing binding fiscal constraints, governments in developing countries have turned to external financing, in the form of tied foreign aid programs, as a significant source of financing public investment.

The question of what form foreign aid should take has led to a growing empirical literature on the link between foreign aid and economic growth during this decade; see Burnside and Dollar (2000), Hansen and Tarp (2000), and Easterly (2003). Relatively recent, Chatterjee, Sakoulis, and Turnovsky (2003) and Chatterjee and Turnovsky (2004) have developed a general equilibrium-growth framework within which this issue can be analyzed. Their results indicate that the consequences of tied and untied aid programs on economic growth and welfare depend crucially upon a number of key structural characteristics of the recipient economy. These include: (i) the costs associated with installing the publicly provided capital (intertemporal adjustment costs), (ii) the substitutability between public and private capital in production (intratemporal adjustment costs), (iii) the degree of access to the world financial market (financial adjustment costs), and (iv) the opportunities for co-financing infrastructure projects by domestic resources, like the domestic government or private sector.

However, even though these efforts, the popular claim on this matter is that aid does not work in practice because it is more "consumed" than invested and evidence seems to confirm this issue. Moreover, people (donors and International Financial Institutions like the World Bank and IMF) are concerned about because there is the presumption that, for various reasons (e.g. corruption, rent-seeking or governments vote buying), aid is eventually not optimally allocated.

In this paper, we construct an optimal two-sector growth model which distinguishes itself from the existing theoretical literature on aid and

growth by its focus on three critical aspects absent from previous analysis. First, we abandon the restrictive assumption that output is produced using one-sector models. Close to the spirit of Benhabib and Farmer (1996), we show how a two-sector model involving consumption and investment notably improves our understanding of the mechanisms operating in the propagation of foreign aid shocks across sectors and, in turn, in the economy. Specifically, we show how aid flows differently alters the marginal valuations of consumption and investment, thereby impacting on the economy's productive capacity and resulting macroeconomic performance. Furthermore, we are able to assess in a better and crystal way how aid should be allocated mostly to the consumption industry. Second, we focus on the interaction between aid and production in two forms: (1) Firstly, and following the "tied" approach on aid, we assume that aid plays a direct productive role in the economy participating itself as an intermediate input in production. (2) Secondly, we introduce a delay in the enrollment of aid in production. Concretely, we assume that a fraction of aid is used up in the production process at each time as intermediate goods or technical expertise while the remaining of it goes directly into capital accumulation in the form of infrastructure projects or plant building that cannot be used in the current period for production but in subsequent periods (lagged aid). In a certain way, we are introducing here a new "*semi-untied*" form of spending aid. Our results suggest that this strategy has a significant positive impact on capital accumulation and in turn on investment. (3) Finally, motivated by the issue that the great majority of people living in poor countries are very needy ones, we assume that they like to receive aid from "donors" (the planner in this case). This presumption is formalized by incorporating it into agents' preferences which, as in Chatterjee and Turnovsky (2006), also admit an elastic labor supply.

Given the complexity of the model, most of the analysis is conducted numerically. The numerical simulations we conduct highlight the significant tradeoff that exists between the impact of foreign aid on consumer welfare between the short and the long run. The ability of the planner to choose between work and leisure alters the allocation of resources across sectors

during a non minor period of time (short run) under aid acceleration. Specifically, we observe that a permanent aid shock generates a *pro-investment* dynamic adjustment lasting almost the middle of the total period, which is made not only by substituting away work effort from consumption toward investment but also by diminishing leisure. However, this behavior is fully reverted in the long run. In fact, our results suggests the endogeneity of labor-leisure choice should play a role in affecting resource allocation decisions just in the short run, just in opposition to found by Chatterjee and Turnovsky (2006). On the contrary, we observe that the planner retakes a relative *pro-consumption* position in the long run and resources are not significantly reallocated respect to their initial values. Looking for an explanation for these results, we would say that the marginal valuations of aid in consumption and investment could be the mechanisms through which aid shocks propagate into the economy in the long run, and the rapid capital accumulation throughout delayed aid helps avoid the need for more work effort.

Summarizing, we offer in this paper a model that makes aid work in terms of increasing (although differently) both consumption and investment, thereby impacting positively on output.

The plan of this chapter is as follows: Section 2.2 introduces the model. A numerical example is offered in Section 2.3, while Section 2.4 is devoted to the dynamics of the model. Finally, Section 2.5 concludes.

2.2 The Model

2.2.1 Technology

Following Benhabib and Farmer (1996), we assume here an optimal two-sector time-discrete economy producing at time investment goods (I_t) and consumption goods (C_t). To produce these goods, capital K_t and labor ($1-L_t$) are needed as the primary factors of production. Put differently, L_t units of leisure are taken by households. These inputs are endogenously

allocated across sectors in such a way that respectively $\mu_{K,t}$ and $\mu_{L,t}$ units of capital and labor are used in the consumption goods industry and the remaining $(1-\mu_{K,t})$ and $(1-\mu_{L,t})$ units are used in the investment sector. In addition, this time in the spirit of the seminal work by Barro (1990), we assume that production also requires the provision of exogenous public services $F_t > 0$ which, for the purposes of the paper, are provided entirely from *foreign aid*. For concreteness, we can think of aid not only as “law and order” services — like Alesina and Rodrik (1994) — but also as foreign technical assistance, certain type of light machinery, medical assistance and so on. We assume that just a fraction of $(1-\theta_t)$ units of this aid is endogenously allocated to production in such a way that $\mu_{F,t}$ units of this fraction go to the consumption industry and the remaining $(1-\mu_{F,t})$ units go to investment. The remaining θ_t units go directly to households therefore increasing their capital stock. As mentioned in the Introduction, aid is firstly used up in the production process at each time as intermediate goods or technical expertise while the remaining of it goes directly into capital accumulation in the form of infrastructure projects or plant building that cannot be used in the current period for production but in subsequent periods throughout the capital stock. In this sense, aid is always assumed as an exogenous intermediate input to be endogenously allocated and having a stepping participation in production: one being instantaneous and the other being lagged. That said, we adopt in this chapter a modified version of the formulation provided by Barro (1990) and Barro and Sala-i-Martin (1995) to yield the following aggregate production functions:

$$C_t = A_t [\mu_{K,t} K_t]^a [\mu_{L,t} (1-L_t)]^b [\mu_{F,t} (1-\theta_t) F_t]^c \quad (1)$$

$$I_t = B_t [(1-\mu_{K,t}) K_t]^a [(1-\mu_{L,t})(1-L_t)]^b [(1-\mu_{F,t})(1-\theta_t) F_t]^c \quad (2)$$

In these equations, A and B are the usual technical parameters (or total factor productivities); $0 < a, b, c < 1$ are the capital, labor, and aid intensities,

respectively. By assuming constant returns-to-scale in both technologies the condition $a + b + c = 1$ holds. Notice that the two industries use identical technology with the exception of the two scaling factors A and B ⁴⁰. Finally, we assume that the capital stock is depreciated at a constant level of δ in one period so that the law of motion of capital has the following structure:

$$K_{t+1} = (1 - \delta)K_t + I_t + P_{F,t} \theta_t F_t \quad (3)$$

In equation (3), P_F represents the international price of aid which is assumed exogenously determined.⁴¹ We think that this exogeneity is pertinent because poor countries have no influence on the formation of this price. The last term in the right-side of this equation involves the assumption that a fraction of aid θ_t is going to capital accumulation as representing infrastructure projects or plant buildings which go to production in subsequent periods (lagged aid assumption).

2.2.2 The central planner problem

We consider the following optimal growth problem:

$$\begin{aligned} & \text{Max} \sum_{t=0}^{\infty} \beta^t U(C_t, \theta_t F_t, L_t) \\ & \left\{ \mu_{K,t}, \mu_{L,t}, \mu_{F,t}, C_t, I_t, K_{t+1}, \theta_t \right\}_{t=0} \end{aligned} \quad (\text{P1})$$

This subject to equations (1) to (3), $K_0 > 0$ given and the corresponding positive constraints (particularly $0 < \mu_{K,t}, \mu_{L,t}, \mu_{F,t} < 1$, $0 < \theta < 1$ and $L_t > 0$). As usual, $\beta < 1$ is the time discounting factor.

⁴⁰ In fact, any relevant insight is gained from assuming different technologies

⁴¹ In this paper, consumption is assumed as the *numéraire* and aid is expressed in terms of these goods.

Notice that the planning board has the task of choosing from among the feasible paths of capital accumulation the one that maximizes the sum of discounted social welfare over time, where social welfare depends not only on the usual labor-leisure structure but also on aid. The inclusion of aid in utility reflects the idea that the benevolent planner also views this resource as a vehicle to give felicity to people. In other words, people become happy receiving infrastructure, plants building and so on.

By means of successive substitutions, one can reduce the optimal control problem above by defining the following Lagrangian⁴²

$$\begin{aligned} \max_{\{\mu_{K,t}, \mu_{L,t}, \mu_{F,t}, \theta_t, K_{t+1}\}_{t=0}^{t=\infty}} L = & \sum_{t=0}^{\infty} \beta^t U(C_t, \theta_t F_t, L_t) \\ & + \sum_{t=0}^{\infty} \beta^t \lambda_t \left\{ (1-\delta)K_t + B_t \left[(1-\mu_{K,t})K_t \right]^a \left[(1-\mu_{L,t})(1-L_t) \right]^b \left[(1-\mu_{F,t})(1-\theta_t)F_t \right]^c + p_{F,t} \theta_t F_t - K_{t+1} \right\} \end{aligned}$$

The interior solution for this optimization problem is characterized by the following first order conditions:

$$U_C(.) \cdot C_t \frac{(1-\mu_{K,t})}{\mu_{K,t}} = \lambda_t I_t \quad (4)$$

$$U_C(.) \cdot C_t \frac{(1-\mu_{L,t})}{\mu_{L,t}} = \lambda_t I_t \quad (5)$$

$$U_C(.) \cdot C_t \frac{(1-\mu_{F,t})}{\mu_{F,t}} = \lambda_t I_t \quad (6)$$

$$-U_C(.) \cdot b \frac{C_t}{(1-\theta_t)} + U_\theta(.) - \lambda_t b \frac{I_t}{(1-\theta_t)} + \lambda_t p_{F,t} F_t = 0 \quad (7)$$

$$-U_C(.) \cdot c \frac{C_t}{(1-L_t)} + U_L(.) - \lambda_t c \frac{I_t}{(1-L_t)} = 0 \quad (8)$$

$$\lambda_t - \beta \left[(1-\delta) + a \frac{I_{t+1}}{K_{t+1}} \right] \lambda_{t+1} = \beta a U_C(.) \frac{C_{t+1}}{K_{t+1}} \quad (9)$$

⁴² In this expression, we have reduced the initial number of control variables by substituting equation (2) into (3).

In this set of equations, λ is the multiplier associated with the law of motion of capital (3). Equations (4) to (6) are the optimal conditions with respect to the allocation variables $\{\mu_K, \mu_L, \mu_F\}$, respectively. Equations (7) and (8) are respectively the optimal condition with respect to θ (the fraction of aid going into capital accumulation) and L (labor), respectively. Equation (9) provides the optimal inter-temporal rule for K_{t+1} ⁴³.

From Equations (4) to (6) is easily verified that the following relationship holds:

$$\mu_{K,t} = \mu_{L,t} = \mu_{F,t} \equiv \mu_t \quad (10)$$

Equation (10) means that input allocations are the same across sectors, i.e., same proportions of capital, labor and aid are allocated in consumption (or investment) at each period of time. This result permits to rewrite equations (1) and (2) as follows:

$$C_t = A_t \mu_t K_t^a [(1-\theta_t)F_t]^b (1-L_t)^c \quad (11)$$

$$I_t = B_t (1-\mu_t) K_t^a [(1-\theta_t)F_t]^b (1-L_t)^c \quad (12)$$

Therefore, like Benhabib and Farmer (1996), the output of this economy can be defined as

$$Y_t \equiv C_t + (A/B)I_t = C_t + p_t I_t = A_t K_t^a [(1-\theta_t)F_t]^b (1-L_t)^c \quad (13)$$

Like in the previous chapter, $p_t = A/B$ also represents the marginal rate of transformation of consumption into capital goods (henceforth, *MRT*). Countries with lower p_t are more efficient at producing investment goods, requiring a lower sacrifice in terms of consumption and, in turn, of welfare in

⁴³ We have expressed the first-order conditions as a function of I_t in order to simplify the presentation.

order to produce one unit of capital. Using this definition, we note that the level of F does not affect this rate.

Two main facts are worth highlighting from equations (11) to (13).

First, it is easily checked from equation (13) that an increase as in leisure L reduces the level of output. However, an increase in the fraction of lagged aid θ causes an ambiguous impact on output⁴⁴. Second, and recalling here that one of the main purposes of the paper is to know how foreign aid is allocated across sectors, it is easily followed from equations (11) and (13) that the aid allocation in consumption equals the consumption-to-output ratio, i.e.,

$$\mu_{F,t} = \frac{C_t}{Y_t} \quad (13)$$

Therefore, the model suggests by construction that, contrary to the popular claim that aid does work in practice because it is mostly channeled into consumption and not investment, it would be optimal that at least a part of it is significantly allocated to the consumption good sector at each point in time.

We now turn to the analysis of the steady state growth paths.

2.2.3 The steady state paths

For the sake of simplicity, we assume from now a log-linear $U(.)$ as follows:

$$U(.) = \log C_t + \eta \log(\theta_t F_t) + \gamma \log L_t \quad (14)$$

⁴⁴ In other words, $\frac{\partial C}{\partial L}, \frac{\partial I}{\partial L}, \frac{\partial Y}{\partial L} < 0$.

We assume that both $0 < \eta < 1$ and $0 < \gamma < 1$, η representing the relative importance of lagged aid in utility and γ the relative importance of leisure. Equations (1) to (3) plus the first order conditions (6) to (9) and equation (10) define a set of seven equations for seven unknowns $(\hat{\mu}, \hat{\theta}, \hat{L}, \hat{K}, \hat{C}, \hat{I}, \hat{\lambda})$. By getting rid of now the multiplier, it is quite simple to prove that the long-term levels are determined by the following restrictions:

$$-c \frac{1}{(1-\hat{\theta})\hat{\mu}} + \frac{\eta}{\hat{\theta}} + \frac{(1-\hat{\mu})}{\hat{\mu}\hat{I}} p_F \cdot F = 0 \quad (15)$$

$$\frac{\hat{L}}{(1-\hat{L})} - \frac{\gamma\hat{\mu}}{b} = 0 \quad (16)$$

$$\frac{(1-\hat{\mu})}{\hat{\mu}} \left[1 - \beta \left[(1-\delta) + a \left(\delta - \frac{p_F \hat{\theta} \cdot F}{K} \right) \right] \right] = \beta a \frac{\hat{I}}{\hat{K}} \quad (17)$$

$$\delta \hat{K} = \hat{I} + p_F \hat{\theta} \cdot F \quad (18)$$

$$\hat{C} = A \hat{\mu} \cdot \hat{K}^a ((1-\hat{\theta})F)^b (1-\hat{L})^c \quad (19)$$

$$\hat{I} = B(1-\hat{\mu})\hat{K}^a ((1-\hat{\theta})F)^b (1-\hat{L})^c \quad (20)$$

The system above has two characteristics. It's highly nonlinear [see for example equations (15) and (17)], and non-recursive which makes it impossible to reduce its dimension significantly. Besides, the nature of the 6-dimensioned stationary system in that case prevents from any further analytical step. We shall resort to numerical simulations of a calibrated model from now.

2.3 A numerical example

In this section we offer a numerical example of the model described before. We start by presenting a calibrated version of this model⁴⁵. At this point, it is worth mentioning that even though the parameterization process involves

⁴⁵ We use Dynare, the package developed by Juillard (2002), for the simulations and stability assessment of nonlinear forward-looking variables.

the use of usual values, it also contains several values not found in the literature which were adjusted to replicate indirect data, particularly shares such as consumption-to-GDP, capital-to-GDP, aid-to-GDP (among others). We follow the same assumption made by Castro (2005) which identifies the marginal rate of transformation of consumption into capital goods (p_t) directly from the relative investment price data. In other words, p_t is calibrated here as representing the economy's relative price of investment goods⁴⁶. The results of the calibration procedure are given in Table 2.1.

Table 2.1 Values of the parameters in the model

Parameter	Symbol	Value
Time discounting factor	β	0.98
Rate of depreciation of capital	δ	0.11
Capital share	a	0.23
Labor share	b	0.44
Aid share	c	0.33
Aid-lump-sum transfers intensity in utility	η	0.7
Leisure intensity in utility	γ	0.1
Total factor productivity in consumption	A	20
Total factor productivity in investment	B	13
Level of aid	F	0.40
International aid-price	P_F	1

The parameter β , the time discounting rate, and δ , the depreciation rate of capital, have been fixed to some usual values⁴⁷. The parameter a , the capital share, b , the labor share, and c , the aid share have been fixed in order to replicate a poor country whose industries are more intensive in both labor and aid than in capital. For doing this, we take into account some

⁴⁶ At this point, it is worth emphasizing the fact that our paper merely underscores the importance of understanding why relative investment prices differ across countries, which is an important issue in development economics. See more details in Section 1.4.

⁴⁷ See, for example, Boucekine *et al.* (2006).

values found in the literature⁴⁸. For fixed values of η and γ , the level of the TFPs A and B ; the level of aid F and the international price of aid P_F have been chosen so as to have share of consumption in GDP around 86%; share of aid in GDP around 2.34%; share of physical capital in GDP, i.e., pK/Y , close to 1.5 and a relative price of investment goods near 1.5. Data on the ratio consumption to GDP was taken from the Penn Tables 6.0; data on both the ratio capital to GPD and the relative price of the investment goods was taken from Castro (2005), and data on the ratio aid to GDP was taken from Burnside and David Dollar (2002)⁴⁹. Table 2.2 shows the long run properties of this parameterization.

Table 2.2: The long term implications of the parameterization

Endogenous variable (*)	Symbol	Value
Share of aid transfers	$\hat{\theta}$	0.59
Share of aid in consumption	$\hat{\mu}$	0.86
Ratios		
Consumption to output	C/Y	0.86
Capital to output	pK/Y	1.58
Aid to output	F/Y	0.0252
Relative price	$\hat{p}$	1.536

Recalling that the one of the main objectives of this paper is to investigate how aid inflows should be allocated into the economy, we see from the table above that aid should be firstly and mostly used to increase households' capital stock by giving lump-sum capital transfers. In fact, we observe that the 59% of aid has gone directly to families and the rest has gone immediately to production. In other words, 61% of aid in production is lagged, i.e., it goes to production in future periods. Moreover, the long run value of $\hat{\mu}$ suggests that the 86% of aid put instantaneously in production should be allocated to the consumption sector. In short, under the assumption that people like to receive aid from the planner, the model

⁴⁸ Particularly, Boucekine *et al.* (2006b) fix the capital share to 0.35.

⁴⁹ For more details, see the Appendix B.

predicts that it should be optimal to allocate aid in the long run in such a way of firstly —and mostly— increasing households' equity rather than to put it directly in production. Put differently, the great part of aid going to production should be delayed.

2.4 Dynamics

In this section we first study the transition dynamics to the steady state growth paths and then we move to the analysis of the short-term dynamics. The dynamics system is reported in the appendix. We simulate the calibrated version of this system⁵⁰. In order to illustrate the effects of the amount of aid into the economy, we additionally considers another numerical example which only differs from the benchmark in the value of F . Concretely, we consider the case where F equals two times the benchmark value. Table 2.3 shows the long run properties of the two parameterizations.

⁵⁰ We use Dynare, the package developed by Juillard (2002), for the simulations and stability assessment of nonlinear forward-looking variables.

Table 2.3: Long-term implications of the parameterizations

Endogenous variables	Symbol	BM(*)	High-F ($F = 0.8$)
Consumption	$\hat{C}$	13.9344	20.7961
Investment	$\hat{I}$	1.2305	1.73201
Capital stock	$\hat{K}$	16.3048	24.5512
Output	$\hat{Y}$	15.8275	23.4607
Leisure	$\hat{L}$	0.21060	0.211737
Fraction of lagged aid	$\hat{\theta}$	0.59233	0.597001
Share of aid, leisure and capital in consumption	$\hat{\mu}$	0.880393	0.886422

(*) Benchmark model

When the central planner is ruling a better endowed economy via F , we first note that the inter-sectoral assignment of resources is quite similar to the benchmark case. In fact, we just observe an increase in $\hat{\mu}$ by 0.7%. In addition, the amount of labor shows a small increase by 0.5%. Likewise, the fraction of aid going directly to increase capital stock's households is slightly increased by 0.8%. In short, we see that the amount of aid seems not to alter too much the planner's decision-making process allocating resources in the long run. Finally, as expected from equation (18), the level of capital stock is significantly augmented by 50.6%. As a result, it is verified that consumption rises more than investment therefore causing that the observed gains in output are driven by the former sector (consumption). Summarizing, this exercise suggests that the sectoral marginal productivity of aid would be the main mechanism behind the optimal long run allocation of aid. Concretely, it seems to be case where the marginal productivity of aid in consumption is bigger than the marginal productivity of it in investment. On the other hand, unlike Chatterjee and Turnovsky (2006), leisure would play no long run role in the propagation of foreign aid shocks. In addition, the long run gains in investment are mostly driven by the increase in capital stock throughout the lagged amount of aid instead of inter-sectoral reassignments of resources.

We now turn to the short term dynamics. We consider a permanent and unexpected shock in the level of aid F affecting the economy from $t =$

0. The dynamic simulations are conducted on the calibrated models described in Section 2.3. The magnitude of the shock is set to 1%. The solution paths are given in Figure 2. Each solution path represents the evolution of **the percentage deviation** across time of a given variable respect to its initial steady state value. This evolution is measured in the vertical axe. The horizontal axe measures periods.

2.4.1 Aid allocation, leisure, and economic behavior under aid acceleration

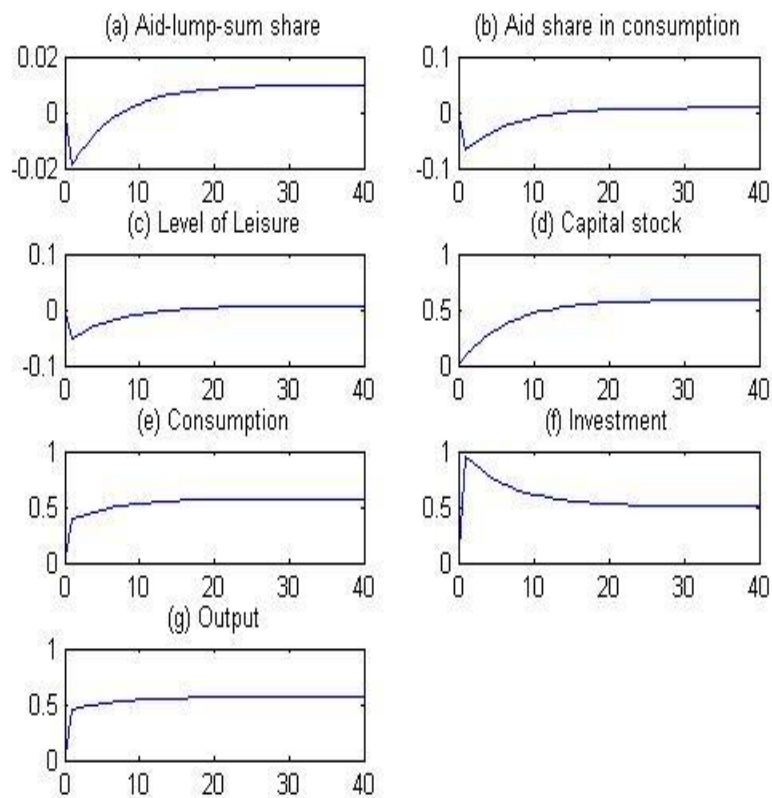
Let us now analyze how this economy reacts to the shock. The main finding to be highlighted from the simulation is:

(i) When the economy benefits from new aid inflows, we observe that aid is put instantaneously in production during a significant part of the total period instead of being lagged (going to capital accumulation). In fact, we see that the fraction of lagged aid θ is reduced. See Figure 2(a)⁵¹. Simultaneously, we observe a reassignment of resources (capital stock, aid and work efforts) in favor of investment lasting around 20 periods. See Figures 2(b)-2(c). We also see that this sector drives the gains in output during a major part of the total period (see Figures 2e-g). Under perfect foresight, we know that the planner will try to correct sectoral imbalances as much as possibly, i.e., until this is compatible with social welfare maximization. This issue explains then this short run *pro*-investment reallocation of resources. After this, (from the middle of the entire period), the optimal allocation of inputs benefit the consumption industry more than the investment one and resources allocation show very small changes respect to its initial situation. In other words, it is seems to be the case where the marginal productivity of aid in consumption is bigger than the marginal productivity of it in investment in the long run. In addition, the simulations suggest that the endogeneity of labor-leisure choice should play just a short run role in the propagation of foreign aid shocks in terms of affecting resource allocation decisions. In the long run, its role would be almost neutral. Overall, we observe that the impact of

⁵¹ We have named this variable "Aid lump sum share".

foreign aid on economic growth is positive. However, the economy absorbs partially the shock on aid in the long run.

Figure 2: Percentages responses to an increase in the level of F in 1%



2.5 Concluding remarks

In this chapter an optimal two-sector forward-looking growth model involving foreign aid in production is offered. The productive role of aid has two moments: (1) a fraction of aid is endogenously and immediately allocated to consumption and investment. (2) The remaining units of aid go to capital accumulation and are used in production in subsequent periods. Hence, this part of aid is put in production is lagged. The allocation of aid across sectors is also endogenously determined. Preferences obey to both the usual consumption-leisure structure and the issue that people like to receive aid from the planner. Leisure is also endogenously allocated across sectors.

In this framework, it is optimal that aid going immediately to production is allocated mostly to consumption rather than to investment. This result is analytically verified.

Numerical exercises show that it is optimal that the first allocation of aid, i.e., that between production and capital accumulation, is made in favor of this latter option in the long run. In other words, the great part of aid going to production is lagged. In addition, these exercises suggest that the amount of aid has no significant long run effects either on this first allocation or on the allocation of aid *across* sectors. However, it is shown that these small changes are sufficient to increase consumption more than investment therefore provoking that the observed positive long run effects of aid on output are driven by consumption. Simulations made using Dynare show that this behavior is fully reverted in the short run. In other words, a *pro*-investment position is taken by the planner, which takes a significant part of the total period.

In particular, the simulations suggest that the endogeneity of labor-leisure choice should play just a short run role in the propagation of foreign “tied” aid shocks in terms of affecting resource allocation decisions. In the long run, this choice is almost neutral. This result is in opposition to found by Chatterjee and Turnovsky (2006).

From a policy perspective, a modest policy message of the paper is that aid could work. However, the model suggests that it should be optimal that a significant part of aid is lagged in the form of infrastructure projects and plant buildings and put it then in production of goods. Reputed NGOs (Non-Governmental Organizations) would play an important role in distributing this kind of aid to these purposes. This would help, perhaps, to reduce some of the presumptions usually made by donors about the misuse of aid in practice.

We conclude with a final comment. In this paper, we have abstracted entirely from any political economy factors relating to rent-seeking, corruption (or others) which are clearly relevant issues in any foreign aid discussion. Relatively recent work by Acemoglu and Robinson (2000) and others show that the existence of “political elites” and powerful interest groups in poor economies may be a deterrent to investment, technological change, and economic development. Further, the lack of institutions may also inhibit the effects of aid on growth. Clearly, the consequences of these are significant considerations for determining both the nature and composition of foreign aid and are important directions for future research.

Chapter 3

Foreign Direct Investment, Host-Wage Inequality and Economic Development

3.1 Introduction

Despite persistent controversies concerning Foreign direct investment's (*FDI*) instrumental role in developing countries' long-term growth and planning, recent evidence show that these economies trust the convention of positive growth effect of *FDI*, no doubt with valid reasons⁵². A quick survey into the growth pattern of *FDI* in the past four decades would reveal that since 1970s, the combined output of transnational corporations (TNCs) has exceeded the volume of international trade. Not surprisingly, they control over 75% of world trade in manufacturing and account for 75% of all industrial research and development in OECD countries. Overall, *FDI* has been growing four times faster than international trade since 1982,

⁵² *FDI* in developing countries has increased dramatically in recent years (for example, from 80.4 billions of dollars between 1991 and 1995 to 273.5 billions in 2005). Recently, Dr. Manomohan Singh, the Prime Minister of India and the chief architect of India's economic reform, stressed that India requires high *FDI* in many core sectors including tourism and telecom. http://www.atimes.com/atimes/South_Asia/MB24Df01.html

suggesting that *FDI* is playing an increasingly leading role in the era of global economic integration. This has led many economists and policy makers in recent years to adopt an optimistic view that *FDI* should play a key role in economic development and hence it should be encouraged and subsidized. However, as argued and demonstrated in both theoretical and empirical literature, study of the nature of *FDI* is imperative for understanding its impact on welfare gain – which is why many developing countries have engaged in intensive efforts to ease bureaucratic barriers to *FDI*. Vishwasrao and Bosshardt (2001) provide good illustration of this tendency using reference to India⁵³.

A fundamental channel through which *FDI* enters into an economy is via technological diffusion –reflecting the role played by innovation and R&D in development where *FDI* plays both direct and indirect role. However, these positive technological impacts of *FDI* on host economies are not always observed. The existing empirical literature evinces mixed support (Hansen, 2001): even if there is wide agreement that *FDI* is one of the major channels of technology transfer towards developing countries, weak evidence is found supporting the idea that *FDI* generates positive spillovers and potential improvement in welfare for host economies⁵⁴. In short, there is no conclusive evidence of *FDI* effectiveness in developing countries in terms of welfare and positive spillovers. From theoretical perspective, studying the distributive effect of *FDI* on host country's wage inequality can throw light on the direction and magnitude of *FDI* effectiveness. This forms the core of the present paper. We are broadly concerned with host-economy macroeconomic consequence of *FDI*. Specifically, we study the distributive impact of *FDI* on raising wage inequality in developing countries in view of the massive institutional restructuring entailed by the process of liberalization – which has affected, among other things, major changes in the labor market. The relatively recent World Social Situation Report (2005) edited by the UN goes even farther on this claiming that “the *process of economic liberalization is typically marked by greater wage flexibility and the erosion of*

⁵³ See Vishwasrao and Bosshardt (2001).

⁵⁴ See, among many others, Grether (1999)

minimum wages, a reduction in public sector employment, declining employment protection, and the weakening of employment laws and regulations. The desire of developing countries to attract foreign investment and expand exports frequently leads to a “race to the bottom” with labor protection and environmental standards often ignored or compromised, ostensibly to make the countries more competitive in the international market. External competitive pressures therefore restrict the ability of developing countries to pursue key aspects of social policy”.

Surprisingly though sizeable literature exists on the impact of *FDI* on both aggregate welfare and spillovers, distributive aspects of *FDI* on host-country wage inequality have been poorly documented and scarcely quantified with a few exceptions e.g., Parello (2008)⁵⁵. Using a 2-country Schumpeterian model, he finds that the impact of stronger intellectual property rights in developing countries on skill accumulation in North (i.e., developed countries) is negative, and tends to increase the within-country wage inequality. In the South (developing countries), the impact is rather ambiguous and depends on the externality that skill accumulation generates on the process of education. More studies relying on North-South Schumpeterian structure have been developed simultaneously by Dinopoulos and Segerstrom (2007) and Gustafsson and Segerstrom (2007)⁵⁶. In this paper, we develop a simple approach by making research and development (R&D) decision exogenous in the North, and consider only the decision process of the developing countries (i.e. The South). For the purpose, we build a simple two-sector exogenous growth model based on the ideas first put forward by Nelson and Phelps (1966) and exploited later by Boucekkine *et al.* (2006), Benhabib and Spiegel (2005), among others. Consequently, we assume in this paper a catch-up model of technology diffusion involving a small two-sector economy where the first sector produces final goods and the second sector produces “knowledge” (the technological sector). This latter sector adopts or imitates new innovations from abroad. In line with the authors mentioned, we keep the central

⁵⁵ See Parello (2008).

⁵⁶ See Dinopoulos and Segerstrom (2007) and See Dinopoulos and Segerstrom (2007).

assumption that the technological gap can only vanish asymptotically. To produce both goods, two new ingredients are incorporated in the basic models. First, we assume that labor has a *heterogeneous* structure i.e., skilled and unskilled units of labor are allocated across sectors. In addition, we assume that the technology sector always benefits from *FDI* as another input. Putting differently, we assume here that *FDI* enters into the economy primarily through the technological sector, which reflects the idea that multinationals tend to be high-productivity firms which pay relatively high wages.

Furthermore, like Desmet, Meza and Rojas (2008), we also assume a centralized and a planned economy characterized by two main factors: (1) the existence of a benevolent planner controlling for the amount of *FDI* inflows over time and (2), the absence of both domestic investment and net exports. The implication is as follows: on the one hand the sole contribution to capital accumulation in this economy is via *FDI* and, on the other hand, the economy consumes *all* the output. Under these assumptions, the authors conclude that a gradual liberalization is better in terms of welfare, rather than a strategy based on an unrestricted foreign capital entry⁵⁷. Even if our paper is focusing mainly on the impact of *FDI* on wage inequality, attention will be also paid to welfare here. We keep then this structure because it is a reasonable framework for our purpose. Once the model is calibrated, results emerged from the simulations suggest that external policies promoting *FDI* inflows towards countries with environments weakly prepared for pro-technology adoption may increase the wage gap between skilled and unskilled workers there, which is in accordance with previous related empirical studies⁵⁸. In contrast, when the economy benefits from local policies tending to improve this kind of environment, the wage gap may be markedly reduced. This finding *may* give insights into some empirical results showing that wage inequality has decreased after trade liberalization

⁵⁷ This assumption is motivated by the observation that some countries are now pursuing this kind of policy. Brazil is an example of that.

⁵⁸ See, among others, Gopinath and Chen (2003), Beaulieu, Benarroch and Gaisford (2004), Robbins (1996), Feenstra and Hanson (1996), and Wood (1997).

in countries like the Philippines, Singapore, Malaysia and Taiwan but increased in Chile, Colombia, Costa Rica, Mexico and Argentina⁵⁹. In addition, it is shown that the inability of poor countries to affect the world interest rate may cause irrevocable overall economic damages in their races to catch with the world technological frontier. In summary, the results highlighted in our paper are consistent with the view that countries should be cautious in designing their policy towards *FDIs* and *TNCs*. Because macroeconomic performance and policies are closely connected, the central (and modest) policy message implied by the paper is that, even in a pro-gradual-liberalization scenario, *FDI* may become a significant source of host-wage inequality if it is not accompanied by conscious policies enhancing pro-technology adoption environments. The paper is organized as follows. Section 3.2 presents the model, the central planner counterpart and derives its properties in the steady state. Section 3.3 presents the dynamic using numerical simulations. Section 3.4 concludes.

3.2 The model

Consider a semi-open small two-sector economy with the following structure:

$$Y_t = A_{t-1} K_t^a L_{Y,t}^b H_{Y,t}^c \quad (1)$$

$$A_t = (1 - \delta_A) \cdot A_{t-1} + L_{A,t}^\alpha \left(d_t H_{A,t} \right)^\theta FDI_t^\psi (A_{t-1}^0 - A_{t-1}) \quad (2)$$

$$K_t = (1 - \delta) K_{t-1} + FDI_t \quad (3)$$

Equation (1) gives the production function in the final good sector at any date t . Labor is assumed heterogeneous. Thus (L_Y) units of **unskilled** labor, (H_Y) units of **skilled** labor and (K_t) units of capital are used to

⁵⁹ See Das (2002) and Robbins (1996).

produce one unit of final good (Y_t). As usual, we assume constant returns-to-scale for this technology, which imposes the usual restriction for the parameters representing “elasticities” in production, namely, $a + b + c = 1$. In addition, we assume that the technological progress A is materialized with a one period lag, which reflects the usual assumption that technological spillovers are not instantaneous.

Equation (2) gives the technology used in the imitation (or technology adoption) sector. It captures the stock of *technological knowledge* available at the beginning of period t . Generally speaking, it may be seen, in part, as a combination of the ideas put forward firstly by Nelson and Phelps (1966) and exploited later, by Boucekkine *et al.* (2006), Benhabib and Spiegel (2004), among others. In the spirit of the latter works, the functioning of this technology is as follows.

We assume that $L_{A,t}$ units of **unskilled** labor, $H_{A,t}$ units of **skilled** labor and FDI_t inflows are required as the primary factors of production of knowledge at any date t . In other words, it is assumed that the flow of *foreign direct investment* (FDI) enters the economy primarily through this imitation sector. In addition, it is assumed that the stock of technological knowledge suffers certain type of depreciation over time, which is captured by δ_A . For simplicity, we assume a constant rate for this parameter. According to Galor and Tsiddon (1997), this depreciation may occur because technological change or the rate of adoption of new technologies is subject to different kind of losses coming from the lack of complementarities between the new knowledge (created or adopted) and the deep productive structures of the economy..

Furthermore, we assume constant returns-to-scale in this sector. Thus the condition $\alpha + \theta + \psi = 1$ is imposed for the respective input intensities in this sector. Finally, in the spirit of Boucekkine *et al.* (2006), we also include the exogenous variable d_t which captures any potential shock to this sector. For example, d_t may represent an exogenous improvement of the productivity of skilled labor in the imitation sector or a trade policy

reform easing technology transfers⁶⁰. The whole equation (2) describes the diffusion of the frontier technology imported from the North, here formalized by the exogenous variable A_t^O , through the imitation process. More precisely, equation (2) specifies the technological catching-up process at work in the South. As such, it's a more involved reformulation of Nelson and Phelps' mechanism.

Equation (3) gives the law of motion of capital. As in Desmet *et al.* (2008), we assume to simplify the exposition that it does not involve domestic investment. Thus the *sole* source of capital accumulation (from an initial known capital endowment) is foreign direct investment. In fact, this feature of the model allows to fully isolating and understanding the potential effects of *FDI* on the economy, which is the main objective of this paper. The amount of capital at any date t is entirely used in the final good sector. As usual, we assume that the capital stock is depreciating at a constant rate δ .

Like Boucekkine *et al.* (2006), the technological gap at time t , i.e., TG_t , is defined as $\frac{A_{t-1}^O - A_{t-1}}{A_{t-1}}$, which by Equation (2) takes the form

$$TG_t = \frac{1}{L_{A,t}^\alpha (d_t H_{A,t})^\theta FDI_t^\psi} \left(\frac{A_t}{A_{t-1}} - (1 - \delta_A) \right)$$

It follows that the technological gap depends primarily on the adoption efforts (L_A, H_A) and the exogenous productivity variable d_t . Additionally, we observe that it also depends on *FDI* which is novel ingredient compared to pre-existing studies. In this framework, the technological gap is always strictly positive and it can only vanish asymptotically, which is a very known and remarkable property of Nelson-Phelps' adoption models. Like

⁶⁰ As in Boucekkine *et al.* (2006), we assume that $d_t < 1 \forall t$ in order to ensure that A_t in Equation (2) is a strict convex combination of A_{t-1} and A_{t-1}^O . Hence, we always have a situation in which $A_{t-1} < A_t < A_{t-1}^O$ as long as $L_{A,t}$, $H_{A,t}$ and *FDI* are nonzero.

Boucekkine *et al.* (2006), the technological gap goes to zero if and only if labor assignments (L_A, H_A) or the exogenous variable d_t go to infinity when time tends to infinity. There is no way to obtain the same property with unrestricted *FDI*. In this paper we assume that the total amounts of unskilled labor as well as the total amount of skilled labor resources are limited at any time. Additionally, no trend is assumed for d_t . Put in another way, the following labor resources constraints are imposed:

$$L_{A,t} + L_{Y,t} = L \quad (4)$$

$$H_{A,t} + H_{Y,t} = H \quad (5)$$

where L and H are two positive constants. Hereafter, we will assume perfect mobility of both unskilled and skilled labor across sectors.

With respect to the possibility of unrestricted *FDI* letting in the economy, we rule out this option in a way similar to Desmet, Meza and Rojas (2008). More precisely, we assume that the planner determines the optimal path of foreign capital inflows at any date by controlling for the level of capital stock desired in $t+1$. As soon as the quota for a given period is reached, no further capital is allowed to enter. Like these authors, we assume that the following inequality is enough for attracting capital inflows towards the host economy:

$$r_t = MPK - \delta \geq r^* \quad (6)$$

where r^* is the world interest rate, which is assumed exogenous throughout this paper (Small Country assumption). Equation (6) simply means that *FDI* flows into the host economy as long as the real domestic return to capital (marginal productivity of capital (*MPK*) minus capital depreciation) is larger than or equal to the world interest rate r^* .

Lastly, we follow the same structure proposed in the published paper by Desmet *et al.* (2008) which –for the sake of simplicity- considers an economy with no domestic investment and net exports. As mentioned, we do think that these strong assumptions are suitable for our objectives, namely, to know the macroeconomic impact of *FDI* on host-economy, particularly on wage inequality. In other words, like Desmet *et al.* (2008), we are not interested in understanding the incentives pursued by Transnational Corporations to install in the South. Hence, the following identity is imposed:

$$Y_t = C_t \quad (7)$$

3.2.1 The central planner problem

We consider the following optimal growth problem:

$$\underset{\{K_t, A_t, L_{A,t}, L_{Y,t}, H_{A,t}, H_{Y,t}, C_t\}}{\text{Max}} \sum_{t=0}^{\infty} \beta^t U(C_t) \quad (\text{P1})$$

This subject to Equations (1)-(7), given A_{-1} and K_{-1} , and the corresponding positive constraints (particularly $0 \leq L_A(L_Y) \leq L$ and $0 \leq H_A(H_Y) \leq H$). $U(\cdot)$ is a standard utility function and $\beta < 1$ is the time discounting factor. We shall consider a logarithmic utility function in the explicit computations of this paper. Nonetheless, the optimality conditions associated with the optimization problem above will be stated for a general standard utility function to unburden the presentation. Before optimizing, we first substitute equation (3) into (2) and equation (1) into (6)-(7). Consequently, these substitutions yield the following Lagrangian for this maximization problem:

$$\begin{aligned} L = & \sum_{t=0}^{\infty} \beta^t U(C_t) + \sum_{t=0}^{\infty} \beta^t \lambda_{A,t} \left\{ (1-\delta_A)A_{t-1} + L_{A,t}^{\alpha} (d_t H_{A,t})^{\theta} (K_t - (1-\delta)K_{t-1})^{\psi} (A_{t-1}^0 - A_{t-1}) - A_t \right\} \\ & + \sum_{t=0}^{\infty} \beta^t \omega_{L,t} \{ L - L_{A,t} - L_{Y,t} \} + \sum_{t=0}^{\infty} \beta^t \omega_{H,t} \{ H - H_{A,t} - H_{Y,t} \} + \sum_{t=0}^{\infty} \beta^t \lambda_{Y,t} \{ A_{t-1} K_t^a L_{Y,t}^b H_{Y,t}^c - C_t \} \\ & + \sum_{t=0}^{\infty} \beta^t \varphi_{r,t} \{ a A_{t-1} K_t^{a-1} L_{Y,t}^b H_{Y,t}^c - \delta - r^* \} \end{aligned}$$

In this expression, the set of variables $\{\lambda_A, \lambda_Y, \omega_L, \omega, \phi_r\}$ contains the multipliers associated with the imitation technology (2), the goods market clearing (7), the labor markets clearing (4)-(5), and the arbitrage condition (6), respectively. Notice that, by construction, ω_L and ω_H are the shadow prices of unskilled and skilled labor respectively. We will use them to quantify wage inequality hereafter.

Therefore, the corresponding Kuhn-Tucker conditions for all t are characterized by the following equations:

$$U'(C_t) = \lambda_{Y,t} \quad (8)$$

$$\omega_{L_A} = \frac{\alpha \lambda_{A,t} (A_t - (1 - \delta_A) A_{t-1})}{L_{A,t}} \quad (9)$$

$$\omega_{L_Y} = \lambda_{Y,t} b A_{t-1} K_t^a L_{Y,t}^{b-1} H_{Y,t}^c + \phi_{r,t} a b A_{t-1} K_t^{a-1} L_{Y,t}^{b-1} H_{Y,t}^c \quad (10)$$

$$\omega_{H_A} = \lambda_{A,t} \frac{\theta (A_t - (1 - \delta_A) A_{t-1})}{H_{A,t}} \quad (11)$$

$$\omega_{H_Y} = \lambda_{Y,t} c A_{t-1} K_t^a L_{Y,t}^b H_{Y,t}^{c-1} + \phi_{r,t} a c A_{t-1} K_t^{a-1} L_{Y,t}^b H_{Y,t}^{c-1} \quad (12)$$

$$\begin{aligned} \lambda_{A,t} \cdot \psi \frac{A_t - (1 - \delta_A) A_{t-1}}{FDI_t} + \lambda_{Y,t} a A_{t-1} K_t^{a-1} L_{Y,t}^b H_{Y,t}^c &= \phi_{r,t} (1 - a) a A_{t-1} K_t^{a-2} L_{Y,t}^b H_{Y,t}^c \\ + \beta \lambda_{A,t+1} \cdot \psi (1 - \delta) \frac{A_{t+1} - (1 - \delta_A) A_t}{FDI_{t+1}} \end{aligned} \quad (13)$$

$$\begin{aligned} \beta \cdot \lambda_{Y,t+1} K_{t+1}^a L_{Y,t+1}^b H_{Y,t+1}^c + \beta \cdot \phi_{r,t+1} a K_{t+1}^{a-1} L_{Y,t+1}^b H_{Y,t+1}^c \\ = \lambda_{A,t} - \beta \cdot \lambda_{A,t+1} \left\{ (1 - \delta_A) - L_{A,t+1}^\alpha (d_{t+1} H_{A,t+1})^\theta FDI_t^\psi \right\} \end{aligned} \quad (14)$$

$$\begin{aligned} \phi_{r,t} (a K_t^{a-1} L_{Y,t}^b H_{Y,t}^c - \delta - r^*) &= 0, \\ \phi_{r,t} \geq 0 \quad \text{and} \quad a K_t^{a-1} L_{Y,t}^b H_{Y,t}^c - \delta - r^* &\geq 0 \end{aligned} \quad (15)$$

Equation (8) gives the optimal condition for C_t . Equations (9) to (12) are the optimality conditions with respect to the unskilled and skilled labor in the production and technology sectors respectively. Since both types of

labor are perfectly mobile across sectors, the marginal productivity of each factor is equalized across sectors. Using this property (which crystal clear is equations (9)-(10) on one hand, and in equations (11)-(12) on the other), we are able to capture the level of wage inequality in the economy as follows:

$$\Delta\omega_t = \frac{\omega_{H,t}}{\omega_{L,t}} = \frac{\theta \cdot L_{A,t}}{\alpha \cdot H_{A,t}} \quad (16)$$

Besides, it is easy to prove from the same equations (9) to (12) that the following equation expressing skilled-unskilled labor equilibrium allocations across sectors holds for all t :

$$\frac{b \cdot L_{A,t}}{\alpha \cdot L_{Y,t}} = \frac{c \cdot H_{A,t}}{\theta \cdot H_{Y,t}} \quad (17)$$

Equation (13) gives the optimal condition with respect to K_t (i.e., it represents the Euler equation obtained from Ramsey growth models). Equation (14) is the optimal condition for knowledge accumulation A_t . Like Boucekkine *et al.* (2006), we observe that, by substituting equation (8) into it, the marginal productivity of knowledge (evaluated in terms of the marginal utility at $t+1$ because of the timing) should be equal to the present value of its marginal cost. Equation (15) is the Kuhn-Tucker condition for the arbitrage relationship (6).

Let us now to investigate the steady state growth paths.

3.2.2 The steady-state paths

From this section, we shall explicitly use the logarithmic utility function. After successive and tedious algebraic operations on equations (1)-(15) (basically to remove all the multipliers except the one associated with the interest rate arbitrage condition), we can obtain the steady-state system allowing to compute the variables' levels along the steady-state growth paths (we shall

omit the upper-bar symbol designed for levels just above to unburden the presentation):

$$\begin{aligned}
\psi [1-\beta] \left(\frac{b}{\alpha} \right) \cdot \left(\frac{L_A}{L_Y} \right) \cdot \left[1 + \phi_r \frac{aY}{K} \right] + a \frac{FDI}{K} &= \phi_r (1-a) \frac{aY}{K} \frac{FDI}{K} \\
\beta &= \left(\frac{b}{\alpha} \right) \cdot \left(\frac{L_A}{L_Y} \right) \cdot \left[1 - \beta \left[(1-\delta_A) - L_A^\alpha (dH_A)^\theta FDI^\psi \right] \right] \\
K &= \delta \cdot FDI \\
\delta_A &= L_A^\alpha (dH_A)^\theta FDI^\psi (A^o - A) \\
L_A + L_Y &= L \\
H_A + H_Y &= H \\
\frac{b \cdot L_A}{\alpha \cdot L_Y} &= \frac{c \cdot H_A}{\theta \cdot H_Y} \\
Y &= AK^a L_Y^b H_Y^c \\
Y &= C \\
r &= \frac{aY}{K} \\
\phi_r (r - \delta - r^*) &= 0, \quad \phi_r \geq 0 \quad \text{and} \quad r - \delta - r^* \geq 0
\end{aligned}$$

Notice that this set of equations contains 11 equations for 11 unknowns: the unknowns are $\{L_A, L_Y, H_A, H_Y, K, FDI, A, Y, C, r, \phi\}$. The above system has three characteristics. It's highly nonlinear (see for example the second equation of the system above), non-recursive which makes it impossible to reduce its dimension significantly, and it is potentially non-differentiable. The non-differentiability comes from the slackness conditions as featured in the last item of the system above. Clearly, the interest rate arbitrage condition, being an inequality, potentially yields two regimes, the constrained (when the domestic interest rate is equal to the international one) and the unconstrained (when the domestic rate is strictly

higher than the international). The next proposition shows that the unconstrained regime is impossible in the long-run.

Proposition 1: *Since $0 < \alpha, a, b < 1$, and $\beta < 1$, the unconstrained regime is impossible in the long run.*

Proof: Using the slackness conditions, an unconstrained regime implies $\phi_r = 0$. Using this property of the unconstrained regime in the first equation of the stationary system above, it is easily verified that either the factor $(1 - \beta(1 - \delta))$ or a should be negative for the ratios $\frac{L_A}{L_Y}$ and $\frac{FDI}{K}$ remain positives. However, these conditions would impose either $a < 0$ or $\beta > 1$, which is contrary to the assumption made on these parameters. ■

Hence, the unique possible stationary equilibria are the constrained ones, where the domestic interest rate is equal to the international. Unfortunately, the nature of the 11-dimensioned stationary system in that case (as explained just above) prevents from any further analytical step. We shall resort to numerical simulations of a calibrated model from now.

3.3 Dynamics

Let us now study the transition dynamics to the steady state growth paths. To this end we resort to numerical resolution using a parameterized example of the set of equations described in Section 2. The dynamic system (A3) is reported in Appendix A, page 65. We simulate a parameterized version of this system. Consider the following benchmark calibration for the model which is given by the table below:

Table 3.1
The benchmark parameterization

Parameters	Symbol	Value
<i>Production technology (Y)</i>		
Capital share	a	0.40
Unskilled labor share	b	0.32
Skilled labor share	c	0.28
<i>Knowledge technology (A)</i>		
Unskilled labor share	α	0.2
Skilled labor share	θ	0.5
FDI (capital) share	ψ	0.3
Skilled labor productivity	d	0.1
<i>Exogenous variables</i>		
World interest rate	r^*	0.05
Total amount of unskilled labor	L	13
Total amount of skilled labor	H	5
<i>Other parameters</i>		
Time discounting factor	β	0.98
Rate of depreciation of capital	δ	0.10
Rate of depreciation of knowledge	δ_A	0.20
Level of technological progress in the North	A^0	3.0

A first set of parameters is fixed a priori to usual values used in related literature. Accordingly, the psychological discount factor is set to 0.98; the rate of depreciation of capital is 10% and the world interest rate is 5%. The intensities (or “elasticities”) in both production (a, b, c) and technology (α, θ, ψ) are fixed in such a way of allocating more skilled (unskilled) labor in the technology (production) sector. The criterion for choosing a higher value for the skilled labor share in the technology sector is simple: technology is more intensive in this kind of workers because it requires more

specialization. For fixed values of d and δ_A , the levels of L , H and A^0 have been chosen so as to have share of skilled labor in production around 75%; a ratio L/H equal to 2.6 and a level of inequality around 27⁶¹. Like Boucekkine *et al.* (2006), we also pay attention to the likely importance of the institutional and policy aspects. To these ends, we additionally three alternative parameterizations which differ from the benchmark model in the values assigned to A^0 , d and H , respectively. Therefore they can be viewed as comparative statics with respect to these exogenous variables. For concreteness, we consider the cases where A^0 , d and H equal (separately) 1.5 times their respective benchmark values. Table 3.2 shows the long-term figures of the three parameterizations and some properties of the induced stationary states.

⁶¹ In a country like Chile, the total labor force is composed by 7.200.000 workers. The total unskilled labor force (L) is close to 5.040.000 people (70%) and the remaining 2.160.000 (30%) workers are considered as skilled labor (H). So, the ratio L/H is equal to 2.33. In addition, according to the last CASEN 2006 enquiry, the level of income inequality is, on average, around 1:29. This means that the average income received by skilled chilean workers is 29 times bigger than that received by unskilled ones. See The National Institute of Statistics' web page www.inec.cl and CASEN 2006 enquiry's web page www.Casen2006.cl, visited in December 2010.

Table 3.2
Long-term implications of the calibrations

Endogenous variable	Symbol	BM(*)	High A ^o	Values	
				High-d	High-H
Adoption efforts					
Unskilled labor	L_A	1.52529	1.75315	1.36543	1.32338
Skilled labor	H_A	1.37626	1.54068	1.25556	1.83457
Production efforts					
Unskilled labor	L_Y	11.4747	11.24685	11.6346	11.6766
Skilled labor	H_Y	3.62374	3.45932	3.74444	5.66543
Inflows					
FDI	FDI	8.00174	15.7304	8.33154	10.1727
Aggregates					
Consumption	C	50.0109	98.3149	52.0721	63.5792
Output	Y	50.0109	98.3149	52.0721	63.5792
Technology					
Technological progress	A	2.76764	4.23327	2.79722	2.80475
Technological gap	TG	0.08395 63	0.0630069	0.0724925	0.06961 39
Ratios					
Inequality	$\Delta\omega$	27.7072	28.4478	27.1877	18.034

(*) Benchmark model

From this table, three main observations can be made:

(i) Like Boucekkine *et al.* (2006), a technological acceleration abroad (higher A^0) induces stronger adoption efforts [higher (L_A, H_A)] in the long run. Unlike these authors, these increments are enough to reduce the long run technological gap. The presence of FDI in our model explains this difference. Indeed, as in Boucekkine *et al.* (2006), our model also presents an important arbitrage settlement. When (L_A, H_A) go up, the amount of labor devoted to production decreases, which in turn tends to decrease consumption and output. However, a central planner who cares about consumption per capita should consequently try to alleviate this induced fall in consumption by incorporating in production other available resources; in this case, capital stock throughout high FDI inflows. As a result, we see that FDI may contribute to increase output and reduce the technological gap in the long run. However, it is also shown that they could be a source of long run income inequality.

(ii) When the economy benefits from policy and institutional environments favorable to technology adoption by increasing the skilled labor productivity d , the total optimal long-term amount of labor resources allocated to this activity need not to be large, which implies that (L_A, H_A) are relatively lower than the benchmark case. Consequently, labor efforts in production (L_Y, H_Y) go up and thereby aggregates such as output and consumption increase, which turns the economy more attractive to FDI because the effective marginal productivity of capital (the local interest rate) is bigger than the world interest rate. The planner lets then more FDI enter into the economy, therefore increasing capital stock. As a result, the total factor productivity increases markedly, which reduces in turn the technological gap significantly. In addition, the long-term level of wage inequality is slightly reduced, though.

(iii) When the economy benefits from an institutional and policy environment favorable to technology adoption by augmenting the total amount of skilled

labor H , we observe a reallocation of the adoption efforts in the technology sector characterized for a simultaneous increase in H_A (skilled labor) and a decrease in L_A (unskilled labor). In addition, it is also shown that the labor resources in production (L_Y, H_Y) are both increased, notably H_Y . The remaining variables react as in the previous experiment. However, we observe that the magnitude of the impact on the aggregate variables like consumption, output and capital stock is much higher in this case, while both the total factor productivity and the technological gap remain unaltered with respect to the previous experiment. By contrast, the long-term level of wage inequality is now markedly reduced.

Summarizing, the long run implications of the calibrations suggest, on the one hand, that permanent shocks on H and d reduce both long-term wage inequality. However, shocks on H would have a larger impact on the stationary state than improvements in productivity through variable d , notably in terms of closing wage inequality. In such cases, the first best decisions controlling for FDI inflows towards the economy may help to reduce host-wage inequality in the long run. On the other hand, the impact of H on closing the technological gap is less significant than the impact via d . In addition, it is also shown that technical improvements abroad (higher A^0) make more difficult social welfare maximization because of the presence of the arbitrage settlement mentioned above. We see, from Table 3.2, that this trade-off is surmounted by increasing significantly FDI inflows which implies that modest adoption efforts are necessary in the long run. Overall, we see that FDI is good for spurring growth and reducing the technological gap under technical acceleration abroad. Nevertheless, it may contribute to make host-income inequality more persistent in the long run.

We now turn the short term dynamics. We firstly consider three *permanent* and unexpected shocks affecting the benchmark economy from $t = 0$: a shock on the rate of technical progress abroad A^0 ; a shock on d , and

a shock on H . The magnitude of all the shocks is set to 1%. In addition, and in order to isolate the effect of FDI on wage inequality, we consider another *transitory* shock in the first period on the world interest rate r^* . Contrary to the other cases, the magnitude of this shock is set to -1% , which turns the economy more attractive to FDI . These figures should be kept in mind when the quantitative results are being evaluated.

The solution paths are shown in Figures 3.1 to 3.6. We use Dynare, the package developed by Juilliard (2002), for the simulations and stability assessment of nonlinear forward-looking variables. Details regarding the theoretical fundamentals supporting the structure of this software can be found in Boucekkine (1995) and Blanchard-Kahn (1982). All the pictures in each figure represent the evolution of the percentage deviation of a given variable with respect to its initial steady state value (vertical axis). The horizontal axis shows periods.

Optimal adoption and inequality under technological acceleration

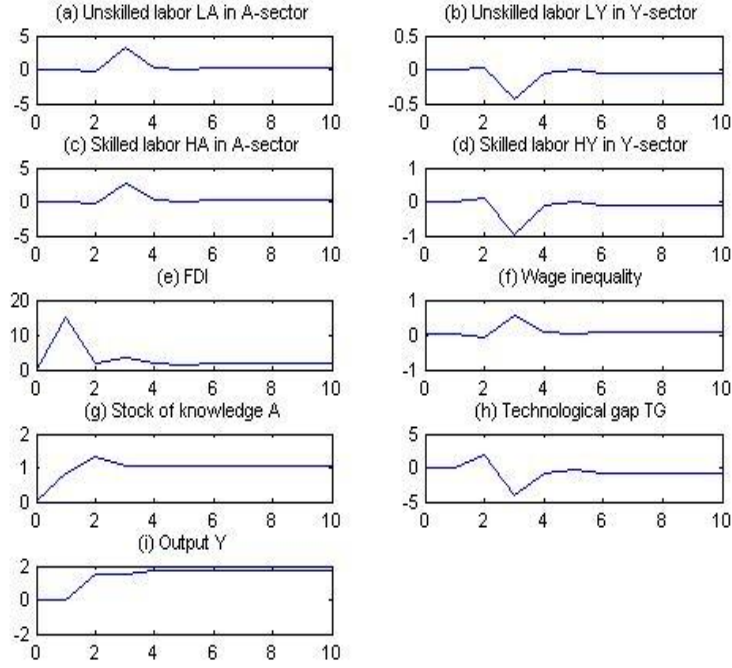
We start analyzing how the economy reacts to the A^0 shock. Figure 3.1 displays the results. The main lesson to be drawn from the experiment is:

(iv) Unlike Boucekkine *et al.* (2006), a technological acceleration in the North through A^0 does induce an intensification of the adoption efforts (L_A, H_A) in the short run. However, this reaction is delayed in two periods and lasts a short period of time. See Figures 3.1(a) y 3.1(c). Since the technological acceleration is permanent, the economy will converge to higher adoption labor long run values. Because labor resources are limited, the opposite is observed in labor devoted to production (L_Y, H_Y) . See Figures 3.1(b) y 3.1(d). On the other hand, we observe high FDI letting into the economy in the very short run followed by a rapid convergence to its (bigger) long run value. See Figure 3.1(e). Like Boucekkine *et al.* (2006), it is worth mentioning here that the timing to the long run convergence in our model depends also on factors such as time discounting (or impatient), the

arbitrage settlement mentioned before and resource competition problems present in the model. As reported by these authors, the economy will converge to higher adoption labor long run values following smooth patterns taking several periods of time. In our case, it is clear however that *FDI* inflows can help to achieve such a convergence more rapidly (four periods) because it allows the planner to care about social welfare maximization without neglecting any sector, particularly the technological one. The problem now is to understand why the first responses imply a lagged reallocating of labor resources favorable to the technological sector while *FDI* flows instantaneously towards the economy once the first shock occurs at $t = 0$. Two reasons (or mechanisms) explain this. First, recall that the local technical progress A is materialized in production with a one period lag which reflects the usual assumption that technological spillovers are not instantaneous. Second, we know that, under perfect foresight and in the absence of adjustment costs, the planner will try to correct sector imbalances as much as possible, i.e., until this is compatible with social welfare maximization and with the arbitrage equation (6). And this is exactly what happens here. In simple words, we see that the planner uses firstly *FDI* to increase sharply the local technical progress A (the “weaker” sector) in the first two periods. See Figure (g). Once these gains in A are incorporated in production in periods 1 and 2, the planner can move labor resources from this sector to the technological one.

Summing up, we observe that *FDI* inflows may help to increase output either in the short or in the long run; they provoke an oscillating short run behavior to the technological gap and they might become a persistent source of income inequality. See Figures 3.1 (f), (h), and (i).

Figure 3.1: Percentages responses to a permanent A^0 shock⁶²



Institutions, policy, optimal adoption and wage inequality

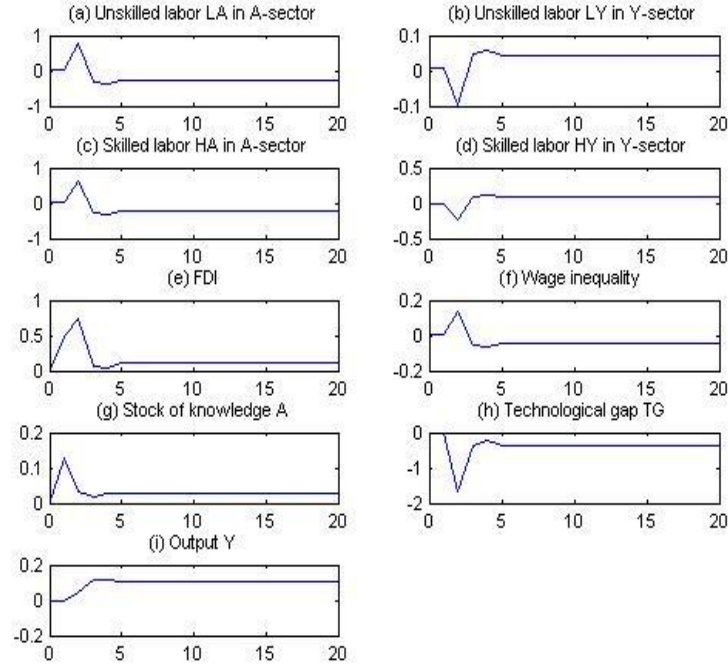
We now study the behavior of the economy when permanent and separated changes in d and H occur. Figure 3.2 displays the results for the former policy variable and Figure 3.3 reports for the latter one. As before, both shocks are conducted on the benchmark economy. The main findings to be drawn from the simulations are:

(v) Like Boucekkine *et al.* (2006), we observe that improvements in the skilled labor productivity d induce a lagged and moderate intensification of the adoption efforts (L_A, H_A) in the short-term. See Figures 3.2(a) y 3.2(c). As a consequence, since the technological progress is materialized with a

⁶² We have omitted the word *periods* under the horizontal axes to unburden the presentation.

one period lag and labor resources are limited, the short-term falls in (L_Y, H_Y) are accompanied by a smooth short-lived *FDI* rise in order to satisfy the arbitrage condition (6) because of the rise in the local interest rate. See Figure 3.2(e). As a result, short-term output and consumption go up. As improvements in productivity turn stronger the performance of the total factor productivity A and in turn the marginal productivity of capital, this short-term reallocation of labor resources becomes fully reverted. As viewed in Section 3.3.2, the economy shows long-term improvements in its aggregates and in the technological gap. However, the level of wage inequality sharply rises in the short-term and it ends up being slightly lower than its benchmark value in the long-term. See Figure 3.2(f). From the previous experiment, it is not hard to understand these first responses. Actually, the same mechanisms presented above explain the two-period lagged reallocation of labor resources. The problem now is to understand why the observed short and long lived increments in *FDI* inflows are significantly lower than those observed under foreign technological shocks. There is a simple reason for this. Since the shock on d is permanent, the economy takes advantage of the improvements in education and/or trade policy and institutions via this variable by raising first the stock of knowledge A (the “weaker” sector) and then production. Hence, *FDI* is viewed just a complementary resource to be put in the economy in the sense that there is no so much need for it.

Figure 3.2: Percentages responses to a permanent d shock⁶³

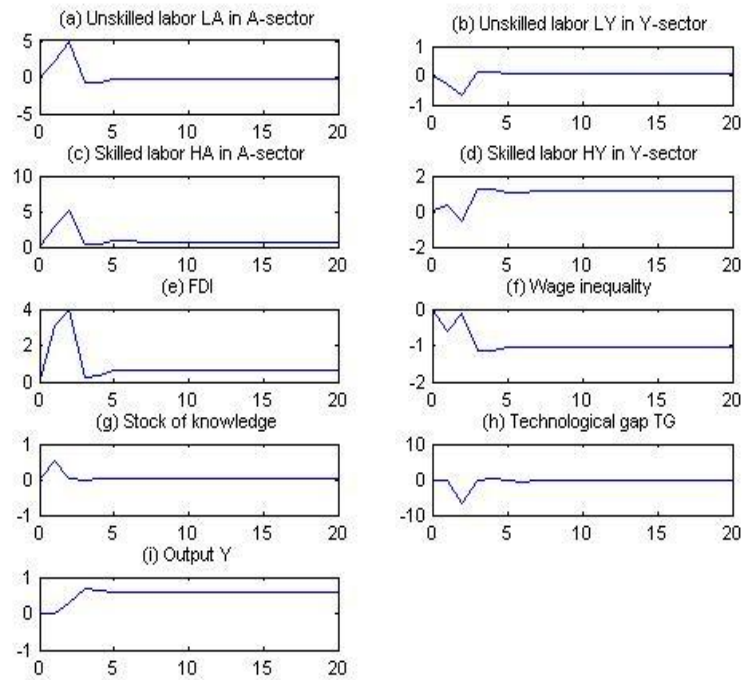


(vi) In contrast to the previous case, we observe that an increase in the total amount of skilled labor H (reduction in the unskilled-to-skilled labor ratio) does provoke a transitory massive adoption effort, which is driven mainly by the increment of the skilled labor resources H_A . See Figures 3.3(a) and 3.3(c). In addition, skilled labor resources in production are also sharply augmented in the short-term, which raises in turn the marginal productivity of capital so augmenting the local interest rate. Consequently, the planner has all the necessary ingredients (incentives) to let in significantly more FDI , which increases capital stock. As expected, the long-term skilled labor values are higher than their benchmark ones. As in Section 3.3.2, long-term aggregate values go up higher than in the previous experiment. However, gains in the technological gap and in turn in the total factor productivity

⁶³ We have omitted the word *periods* under the horizontal axes to unburden the presentation.

remain the same. Furthermore, and more importantly for our objectives, *FDI* they would not be a source of income inequality, neither in the short- nor in the long-term. See Figure 3.2(f).

Figure 3.3: Percentages responses to a permanent H shock⁶⁴



Optimal adoption, income inequality and FDI inflows under changes in the world interest rate

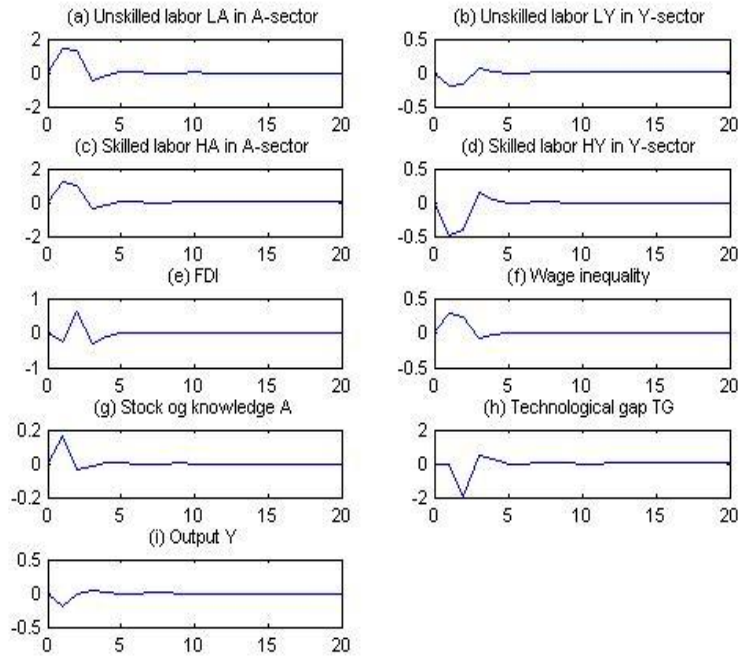
In this experiment we study the effect of a transitory decrease (impulse shock) in the world interest rate. By doing this, we are trying to capture the “pure” effects of *FDI* on income inequality in the short run. Figure 3.5 shows the results. The main lessons to be drawn from the simulations are:

⁶⁴ We have omitted the word *periods* under the horizontal axes to unburden the presentation.

(vi) As expected, a reduction in the world interest augments the left-hand side of the arbitrage condition (6), which turns the economy more attractive to *FDI* inflows. In principle, it would be expected that capital stock and output are both immediately incremented. However, a less expected optimal response is observed, particularly during the first period after the shock. Actually, we see an immediate transitory intensification of the adoption efforts (L_A, H_A) which leads to a temporary reduction in labor (L_Y, H_Y) in production and in turn in consumption. See Figures 3.5(a)-(d). Simultaneously, *FDI* is reduced in the first period. Overall, a reduction in output is shown in the first period. There is reason for this first best response. From Proposition 1, we know that our model does not admit unconstrained regimens in the long run. The simulations suggest that this restriction is also valid in the short run. In other words, the effective local interest rate should be equal to the world interest rate at any time. Put formally, $r_t - \delta = aA_{t-1}K_t^{a-1}L_{Y,t}^b H_{Y,t}^c - \delta = r_t^*$. Hence, the immediate response to a reduction in r^* is to decline the left-side of this equation by diminishing inputs in production. Once the shock is gone, the economy recovers its initial benchmark situation just from period 5. Summing up, Figures 3.5(f) to 3.5(h) show that under external transitory shocks in the world interest rate promoting *FDI*, the economy shows transitory improvements in the technological gap and the local technical progress. However, wage inequality is temporarily increased. More importantly, social welfare maximization may become *incompatible* with a constrained regime in the very short run. See Figure 3.5(i).

Figure 3.5: Percentages responses to a transitory

r^* shock⁶⁵



3.3.4. Robustness analysis

We now study the robustness of the results listed above to changes in the policy variables d and H . To this end, as reported in section 3.3.2, we first study the *permanent* responses of the economy to technological acceleration abroad when structural changes involving separated values of d and H 1.5 (one point five) times bigger than their benchmark. Then, we inquire what happens when a better-shaped and better endowed economy via d and H (together) faces *transitory* shocks hitting the world interest rate r^* in the first period. Figures 3.6 to 3.8 display the results of the simulations. As before, all the pictures in each figure represent the evolution

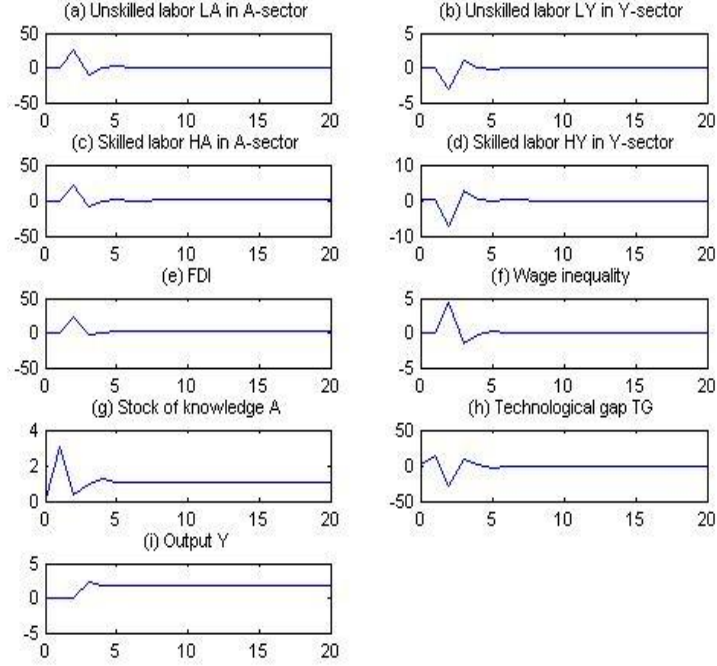
⁶⁵ We have omitted the word *periods* under the horizontal axes to unburden the presentation.

of the percentage deviation of a given variable with respect to its initial steady state value (vertical axis). The horizontal axis shows periods. The main lessons to be highlighted from these exercises are:

(vii) Facing technological accelerations abroad, we observe that the better performed economy via high d also engages in adoption efforts, exactly like the benchmark case. There are however some clear quantitative and qualitative differences. Firstly, we observe that this reaction is more massive and occurs one period less lagged. See Figures 3.6(a)-(d). Consequently, all the remaining variables react following the same behavior observed in the benchmark case, but converge to their long-term values is faster. Concretely, the economy takes one period less of time in reaching its final stationary state. Summing up, it is shown that all the aggregates increase respect to their initial long run values, just as in the benchmark economy. However, even if the short-term value of FDI is markedly increased respect to the benchmark case, its long-term value as well as the long-term values of the technological gap and inequality remain the same.

Figure 3.6: Percentages responses to a permanent

A^0 shock⁶⁶ *High d*



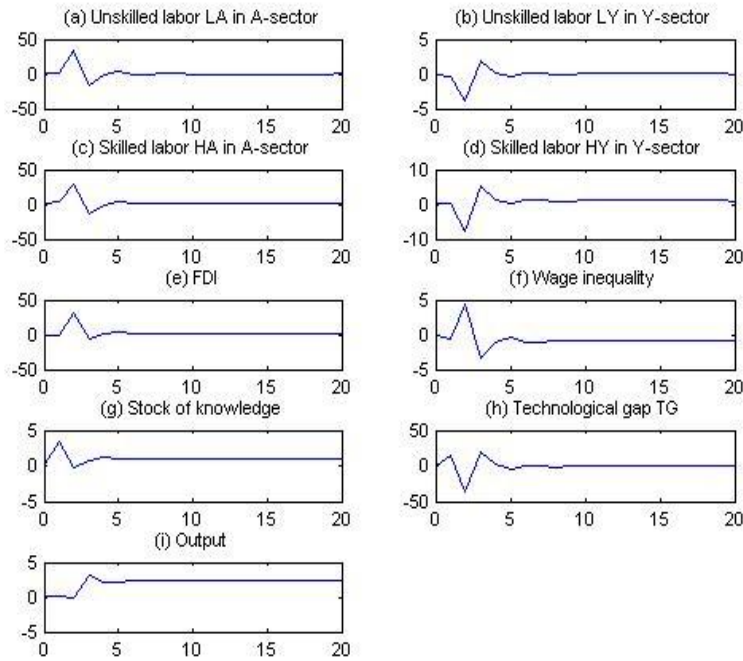
(viii) Facing technological accelerations abroad, we observe that the better performed economy via high H engages in massive and lagged (respect to the initial shock) adoption efforts (L_A, H_A) in the short run, exactly like the benchmark case. There are however some clear quantitative and qualitative differences. Firstly, we observe that this reaction is more massive and occurs one period less lagged, as in the previous experiment. Second, compared to the benchmark case, the value of FDI is higher in the short run and lower in the long run. Consequently, all the remaining variables react following the same behavior observed in the benchmark case, but converge to their long-term values is one period faster. Summing up, it is shown that all the aggregates increase respect to their initial long run values, just as in the

⁶⁶ We have omitted the word *periods* under the horizontal axes to unburden the presentation.

benchmark economy. However, like the previous exercise, the long-term values of the technological gap and inequality remain the same.

Figure 3.7: Percentages responses to a permanent A^O shock⁶⁷

High H

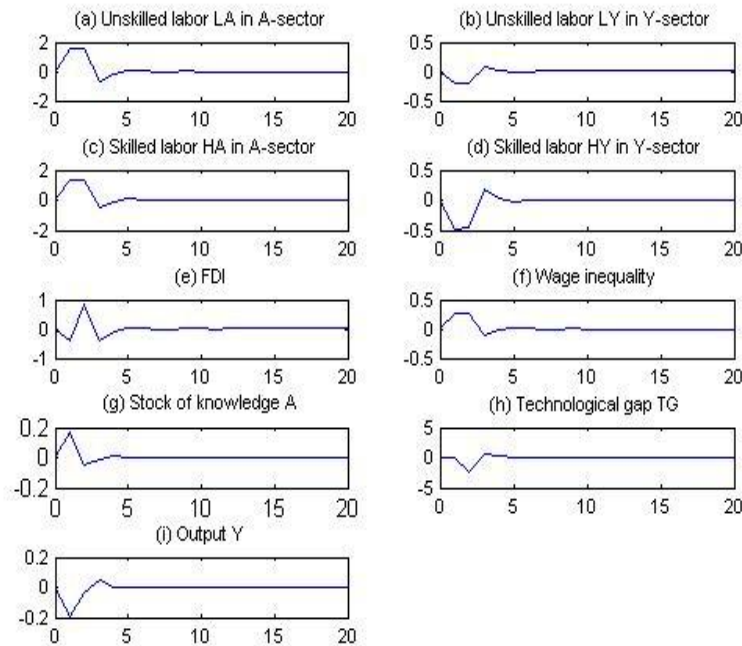


(ix) Facing a transitory shock in the world interest rate promoting FDI inflows, we observe that the better performed economy via d and H shows the same qualitative behavior in all the variables as in the benchmark case. There are two main quantitative differences, though. Firstly, it is verified that the very short run fall in output is bigger in these case. Second, the economy recovers its initial situation one period sooner. Thirdly, FDI and wage inequality are both temporary higher in this case. Overall, Figures 3.8(f) to 3.8(h) confirm under external transitory shocks in the world interest rate

⁶⁷ We have omitted the word *periods* under the horizontal axes to unburden the presentation.

promoting *FDI* , social welfare maximization may become *incompatible* with a constrained regime in the very short run See Figure 3.8(i).

Figure 3.8: Percentages responses to a permanent r^* shock⁶⁸
High both d and H



3.4 Concluding remarks

In this chapter, we build a simple two-sector optimal growth model à la Boucekine *et al.* (2006) and Desmet *et al.* (2008) in the context of a small economy with limited and lagged capacity of technological adoption, scarce skilled labor resources and without any possibilities to affect the world interest rate. We first study the overall effects of *foreign direct investment*

⁶⁸ We have omitted the word *periods* under the horizontal axes to unburden the presentation.

(*FDI*) on this economy. In addition, special attention is paid to its consequences on the host-economy wage inequality. The main results of the dynamics simulations conducted on parameterized versions of the model are fourfold. Firstly, it is shown that those transitory external shocks serving to promote *FDI* inflows (a diminishing in the world interest rate, for instance) would induce some improvements in the economy, particularly in reducing the technological gap. Nevertheless, the level of wage inequality is increased and most importantly, serious short run consequences for the economy in terms of social welfare maximization appear in the very short run under constrained regimens. Consequently, the better endowed is the economy, the higher *FDI* inflows are needed and the higher social welfare is lost. Secondly, it is verified that when the economy permanently benefits from an institutional policy environment favorable to technology adoption, *FDI* seems to play a significant role in boosting the overall economy, even reducing long-term wage inequality.

Quantitatively, the numerical exercises suggest that the design of policies aimed at raising skilled labor instead of improving skilled-labor productivity would be –relatively speaking– more effective in improving the macroeconomic performance, especially for closing host-wage inequality. Thirdly, it is verified that when the economy is facing with a permanent technological acceleration abroad, *FDI* inflows may contribute to increase the economic overall performance either in the short or in the long run. By contrast, it is also shown that they could be a persistent source of income inequality. However, this latter result could change if the economy is better endowed, particularly in the long run. Hence, it is shown that economies having lower unskilled-to-skilled ratio L/H may even reduce their level of wage inequality in the long run when exogenous technological accelerations occur. Said in other words, *FDI* could be just a temporary source of income inequality in this case.

Appendix A: Dynamic system models

A.1 Chapter 1: The dynamic system

$$\frac{(1-\mu_t)}{\mu_t I_t} - \beta \frac{(1-\mu_{t+1})}{\mu_{t+1} I_{t+1}} \left[(1-\delta) + \alpha \frac{I_{t+1}}{K_{t+1}} \right] = \frac{\beta \alpha}{K_{t+1}}$$

$$K_{t+1} = I_t + (1-\delta)K_t$$

$$C_t = A_t \mu_t K_t^\alpha F_t^{1-\alpha}$$

$$I_t = B_t (1-\mu_t) K_t^\alpha F_t^{1-\alpha}$$

$$Y_t = A_t K_t^\alpha F_t^{1-\alpha}$$

A.2 Chapter 2: The dynamic system

$$\frac{(1-\mu_t)}{\mu_t I_t} - \beta \frac{(1-\mu_{t+1})}{\mu_{t+1} I_{t+1}} \left[(1-\delta) + a \frac{I_{t+1}}{K_{t+1}} \right] = \frac{\beta a}{K_{t+1}}$$

$$\frac{\gamma}{L_t} = \frac{c}{1-L_t} + \frac{(1-\mu_t)c}{\mu_t (1-L_t)}$$

$$\frac{-b}{(1-\theta_t)} + \frac{\eta}{\theta_t} + \frac{(1-\mu_t)}{\mu_t I_t} \left[p_{F,t} F_t - \frac{b I_t}{(1-\theta_t)} \right] = 0$$

$$K_{t+1} = I_t + (1-\delta)K_t + p_{F,t} \theta_t F_t$$

$$C_t = A_t \mu_t K_t^a \left[(1-\theta_t) F_t \right]^b (1-L_t)^c$$

$$I_t = A_t (1-\mu_t) K_t^a \left[(1-\theta_t) F_t \right]^b (1-L_t)^c$$

$$Y_t = A_t K_t^a \left[(1-\theta_t) F_t \right]^b (1-L_t)^c$$

A.3 Chapter 3: The dynamic system:

$$\begin{aligned}
& \psi \left(\frac{b}{\alpha} \right) \cdot \left(\frac{\tilde{L}_{A,t}}{\tilde{L}_{Y,t}} \right) \cdot \left[1 + \phi_{r,t} \frac{a\tilde{Y}_t}{\tilde{K}_t} \right] + a \frac{FD\tilde{I}_t}{\tilde{K}_t} - \phi_{r,t} (1-a) \frac{a\tilde{Y}_t}{\tilde{K}_t} \frac{FD\tilde{I}_t}{\tilde{K}_t} + \\
& -\beta \cdot \psi(1-\delta) \left(\frac{b}{\alpha} \right) \cdot \left(\frac{\tilde{L}_{A,t+1}}{\tilde{L}_{Y,t+1}} \right) \cdot \frac{FD\tilde{I}_t}{FD\tilde{I}_{t+1}} \left[1 + \phi_{r,t+1} \frac{a\tilde{Y}_{t+1}}{\tilde{K}_{t+1}} \right] = 0 \\
& - \left(\frac{b}{\alpha} \right) \cdot \left(\frac{\tilde{L}_{A,t}}{\tilde{L}_{Y,t}} \right) \cdot \left[1 + \phi_{r,t} \frac{a\tilde{Y}_t}{\tilde{K}_t} \right] + \\
& \beta \cdot \left(\frac{b}{\alpha} \right) \cdot \left(\frac{\tilde{L}_{A,t+1}}{\tilde{L}_{Y,t+1}} \right) \cdot \left[1 + \phi_{r,t+1} \frac{a\tilde{Y}_{t+1}}{\tilde{K}_{t+1}} \right] \cdot \left[(1-\delta_A) - \tilde{L}_{A,t+1}^\alpha (d_t \tilde{H}_{A,t+1})^\theta FD\tilde{I}_{t+1}^\psi \right] + \beta \frac{1}{\tilde{A}_t} + \beta \phi_{r,t+1} \frac{a\tilde{Y}_{t+1}}{\tilde{A}_t \tilde{K}_{t+1}} = 0 \\
& \tilde{K}_t = (1-\delta) \tilde{K}_{t-1} + FD\tilde{I}_t \\
& \tilde{A}_t = (1-\delta_A) \cdot \tilde{A}_{t-1} + \tilde{L}_{A,t}^\alpha \left(d_t \tilde{H}_{A,t} \right)^\theta FD\tilde{I}_t^\psi (A_{t-1}^0 - \tilde{A}_{t-1}) \\
& \tilde{L}_{A,t} + \tilde{L}_{Y,t} = \tilde{L}_t \\
& \tilde{H}_{A,t} + \tilde{H}_{Y,t} = \tilde{H}_t \\
& \frac{b \cdot \tilde{L}_{A,t}}{\alpha \cdot \tilde{L}_{Y,t}} = \frac{c \cdot \tilde{H}_{A,t}}{\theta \cdot \tilde{H}_{Y,t}} \\
& \tilde{Y}_t = \tilde{A}_{t-1} \tilde{K}_t^a \tilde{L}_{Y,t}^b \tilde{H}_{Y,t}^c \\
& \tilde{Y}_t = \tilde{C}_t \\
& \tilde{r}_t = \tilde{A}_{t-1} \tilde{K}_t^{a-1} \tilde{L}_{Y,t}^b \tilde{H}_{Y,t}^c \\
& \tilde{\phi}_{r,t} (\tilde{r}_t - \delta - r^*) = 0, \quad \tilde{\phi}_{r,t} \geq 0 \quad \text{and} \quad \tilde{r}_t - \delta - r^* \geq 0
\end{aligned}$$

Appendix B: Tables

Table A
Country-Specific Summary Statistics

Country	C/Y (share of GDP)	I/Y (share of GDP)	K/Y	p Relative Price	Aid (percent of GDP)
Argentina	0.67	0.33	1.87	1.59	0.02
Bolivia	0.67	0.33	1.96	0.75	1.80
Brazil	0.69	0.31	1.68	1.12	0.03
Chile	0.60	0.40	2.05	0.96	0.16
Colombia	0.73	0.27	1.43	1.19	0.12
Costa Rica	0.68	0.32	1.36	1.42	1.02
Dominican Republic	0.73	0.27	1.24	1.33	0.60
Ecuador	0.62	0.38	1.96	0.75	0.32
El Salvador	0.72	0.28	0.88	1.93	1.87
Guatemala	0.82	0.18	0.88	1.62	0.49
Guyana	0.67	0.33	2.96	0.96	3.74
Haiti	0.72	0.28	0.53	2.74	1.77
Honduras	0.72	0.28	1.32	1.38	2.19
Jamaica	0.58	0.42	2.70	1.22	1.42
Mexico	0.75	0.25	1.44	1.33	0.02
Nicaragua	0.77	0.23	1.11	1.72	3.14
Paraguay	0.69	0.31	1.03	1.65	0.69
Peru	0.64	0.36	1.71	1.28	0.41
Trinidad y Tobago	0.68	0.32	1.16	3.04	0.07
Uruguay	0.70	0.30	1.60	2.26	0.13
Venezuela	0.71	0.29	1.76	1.28	0.01

Table A
Country-Specific Summary Statistics (continuation)

Country	C/Y (share of GDP)	I/Y (share of GDP)	K/Y	p Relative Price	Aid (percent of GDP)
Syria	0.68	0.32	1.18	1.25	1.86
Turkey	0.77	0.23	N.A	N.A	0.33
Indonesia	0.71	0.19	1.16	1.17	0.39
South Korea	0.66	0.34	1.49	1.19	0.20
Philippines	0.71	0.29	1.35	1.64	0.44
Thailand	0.61	0.39	1.35	1.51	0.24
Malaysia	0.59	0.41	1.68	1.15	0.20
India	0.69	0.31	1.43	1.18	0.26
Pakistan	0.75	0.25	0.97	1.64	0.77
Sri Lanka	0.75	0.25	0.80	2.3	1.17
Mali	0.74	0.26	0.66	2.74	0.20
Niger	0.67	0.33	0.91	1.32	5.38
Nigeria	0.66	0.34	1.22	1.23	0.14
Senegal	0.72	0.28	0.6	2.60	3.63
Sierra Leone	0.69	0.31	N.A	N.A	1.70
Somalia	0.74	0.26	0.82	2.61	4.44
Tanzania	0.57	0.43	0.95	1.61	5.86
Togo	0.59	0.41	1.40	1.39	5.36
Zaire	0.75	0.25	0.39	2.95	2.35

Table A
Country-specific summary statistics (continuation)

Country	C/Y (share of GDP)	I/Y (share of GDP)	K/Y	p Relative Price	Aid (percent of GDP)
Zambia	0.49	0.55	2.79	1.25	4.81
Zimbabwe	0.72	0.28	1.76	1.33	2.34
Botswana	0.51	0.49	1.47	1.51	5.12
Cameron	0.70	0.30	0.66	2.52	1.88
Côte d'Ivoire	0.70	0.30	1.06	2.43	0.85
Ethiopia	0.77	0.23	0.51	2.3	3.75
Gambia	0.73	0.27	0.77	3.47	7.08
Ghana	0.77	0.23	0.77	1.77	1.92
Kenya	0.86	0.14	1.51	1.48	2.34
Madagascar	0.83	0.17	0.16	7.37	2.70
Malawi	0.67	0.33	1.00	1.90	5.65

Notes: Most of the figures for *C/Y* and *I/Y* were taken from the Penn Tables 6.1, and Przeworski and Vreeland (2000)'s database.

The figures for *K/Y* and *p* were taken from Castro's (2005) database and the figures for aid from Craig and Burnside (2000)'s database.

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