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ECONOMIC IMPLICATIONS OF FOREIGN EXCHANGE RATIONING IN ETHIOPIA[1]

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Abstract

Increases in foreign transfers and capital inflows helped spur Ethiopia's economic growth in recent years, but also contributed to a real exchange rate appreciation that reduced incentives for production of tradable goods. Then, beginning in March 2008, following major external shocks, foreign exchange for imports was restricted to avoid excessive drawdown of reserves.

This paper examines the implications of these shocks and policies using a Computable General Equilibrium (CGE) model of the Ethiopian economy. The results show that there are substantial costs to both foreign exchange rationing and real exchange rate appreciation in terms of economic efficiency and income distribution.

Key words: Ethiopia, CGE model, real exchange rate, rents, foreign exchange rationing.

JEL codes: D58 (Computable and Other Applied General Equilibrium Models), O2 (Development Planning and Policy); F31 (Foreign Exchange); O24 (Trade Policy; Factor Movement Policy; Foreign Exchange Policy).

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1. Introduction

Ethiopia enjoyed remarkable economic growth from 2004/05 to 2008/09, in large part due to increases in foreign transfers and capital inflows combined with expanded domestic credit to fund major increases in private and public investments in infrastructure and housing. The agricultural sector also played a major role in the rapid economic growth, as increased efforts in agricultural extension, good weather and improved transport and telecommunications infrastructure, all contributed to increases in agricultural productivity and overall production.

However, this growth was accompanied by a real exchange rate appreciation of 14 percent from July 2004 to January 2007, as nominal exchange rates were kept almost constant while domestic inflation increased. Then, when major external shocks (including increases in world prices of fuel and reduced private transfers) hit the economy, a foreign exchange shortage resulted. Beginning in March 2008, access to foreign exchange for imports was restricted (rationed) to avoid excessive drawdown of foreign exchange reserves, and by July 2008, the real exchange rate appreciation had increased by a further 20 percent (relative to July 2004).[5]

This paper examines the implications of these external shocks and policies, particularly the appreciation of the real exchange rate and the subsequent foreign exchange rationing on the overall economy and household welfare in Ethiopia. Section II presents the macro-economic setting in Ethiopia, focusing on developments from 2004/05 to 2008/09, along with a discussion of the basic analytical framework for assessing the effects of import rationing on the real exchange rate. Section III utilizes a computable general equilibrium (CGE) model of the Ethiopian economy to examine the economy-wide implications of the surge in foreign capital inflows from 2004/05 to 2007/08, the subsequent decline of these flows, and the foreign exchange rationing beginning in March 2008. The final section summarizes the results of the analysis and presents policy implications.

[5] Subsequent nominal depreciation of the Birr reduced the real exchange rate appreciation relative to July 2004 to 30 percent in March 2009.

2. The Macro-Economic Setting: The Investment Boom and Foreign Exchange Rationing

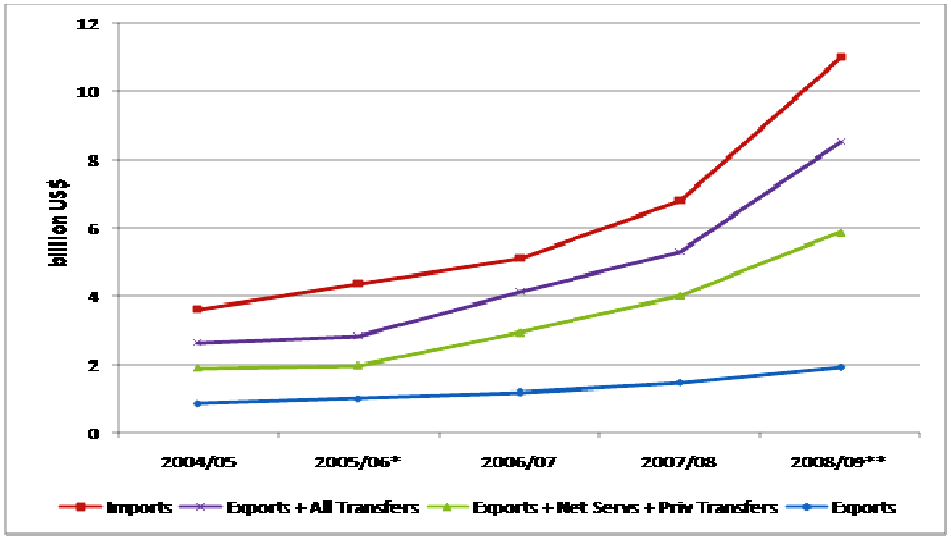
Between 2004/05 and 2007/08, Ethiopia successfully accelerated its economic growth through a deliberate policy of expanded domestic credit to finance private investment and increased foreign borrowing to finance public investment. Increased investment implied increased demand for imports (and for foreign exchange) since private (and public) sector investors had access to foreign exchange to finance imported intermediate and capital goods. At the same time, workers' remittances and private transfers were increasing, supplying resources for private investment in residential housing and other domestic consumption and investment. As a result, merchandise imports surged by 87 percent ($3.2 billion) between 2004/05 and 2007/08. Half of this increase in merchandise imports was financed by a 195 percent increase in private transfers (including workers' remittances); increases in merchandise exports and capital inflows each financed 16-19 percent of the increase in merchandise imports (Table 1).

Table 1: Ethiopia Imports and Import Financing, 2004/05 to 2007/08

	2004/05 mn $	2007/08 mn $	2004/05 to 2007/08 mn $	2004/05 to 2007/08 % change	2004/05 to 2007/08 % of Imports
Imports (Merchandise)	3,633	6,811	3,178	87%	100%
Exports (Merchandise)	847	1,466	619	73%	19%
Net Services	242	160	- 82	-34%	-3%
Private Transfers	811	2,393	1,582	195%	50%
Public Transfers	750	1,312	563	75%	18%
Capital Inflows	983	1,480	496	50%	16%
Subtotal	3,633	6,811	3,178	87%	100%

Source: National Bank of Ethiopia data.

Figure 1: Ethiopia Imports and Import Financing, 2004/05 to 2007/08



Source: National Bank of Ethiopia data.

Higher world prices, increased domestic credit, foreign capital inflows, changes in inflationary expectations and other factors contributed to increases in overall domestic inflation, however, which rose from 11.5 percent in 2004/05 to 64.5 percent in 2007/08[6)]. Inflation has slowed substantially since then, though, and between July 2008 and March 2009, the price level actually fell by 6 percent. Yet, with nominal exchange rates changing little relative to the US dollar, the real exchange rate appreciated by 13.8 percent between July 2004 and January 2008 and by a total of 33.8 percent through July 2008. Nominal depreciation of the Birr (from 9.83 to 12.0 Birr/$) between July 2008 and June 2009 helped reduce real appreciation of the birr to 26.3 percent, but this still represents a major reduction in incentives for production of tradables (export goods and import substitutes) since July 2004.

[6] The Ethiopian fiscal years cited here run from July to June.

Table 2: Ethiopia Nominal and Real Exchange Rates, 2004-2009

Index	Nominal Exchange (Birr/$)	Nominal Exchange Rate (Birr/$) (Index)	World Price Index ($)	World Price Index (Birr)	CPI	Real Exchange Rate Index
July 2004	8.80	100.0	100.0	100.0	100.0	100.0
January 2005	8.83	100.3	102.7	103.0	102.9	100.1
July 2005	8.84	100.5	101.4	101.9	111.5	91.3
January 2006	8.86	100.6	104.1	104.7	112.8	92.8
July 2006	8.87	100.8	108.7	109.6	125.7	87.2
January 2007	8.99	102.1	110.4	112.7	131.6	85.7
July 2007	9.21	104.7	116.8	122.3	143.6	85.1
January 2008	9.40	106.9	127.0	135.7	157.5	86.1
July 2008	9.83	111.7	139.6	156.0	235.8	66.2
January 2009	11.06	125.7	120.0	150.8	217.0	69.5
June 2009	12.00	136.4	121.3	165.4	224.4	73.7
July 04 - June 09 (percent change)	**36.4%**	**36.4%**	**21.3%**	**65.4%**	**124.4%**	**-26.3%**

Source: EDRI and authors' calculations.

Moreover, Ethiopia had been increasingly financing its current account deficit through drawdown of official foreign exchange reserves. From end June 2007 to the end of March 2008, foreign exchange reserves fell by $381 million (equivalent to 13 percent of the value of merchandise imports in that period).[7] (For 2007/08 as a whole (i.e. through June 2008), foreign exchange reserves fell by $264 million in 2007/08 (i.e., an amount equal to 5 percent of merchandise imports in 2006/07), in spite of large inflows of private and public transfers.)

With foreign exchange reserves near zero and import demand in excess of supply of foreign exchange, there were two broad options:

- Devalue the currency so as to reverse the real exchange rate appreciation of the past few years, reducing demand for imports, increasing supply of exports and restoring equilibrium in the market for foreign exchange; or
- Control imports by imposing foreign exchange controls and allow the exchange rate to remain overvalued (and in fact become increasing over-valued)

[7] Average foreign exchange reserves for 2007 were 1.3 billion US dollars (World Bank, Ethiopia at a Glance)..

3. Foreign Capital Inflows, Rationing and the Real Exchange Rate: Analytical Framework

Similar to the goods market, in the foreign exchange markets, the supply of foreign exchange from exports (which includes merchandise and services exports, foreign aid, private transfers and other transfers) plus foreign exchange net capital inflows (equal to the current account deficit) equals demand for foreign exchange from imports. However, the difference between the unrestricted and rationed foreign exchange markets is in the way these market forces (supply and demand) adjust in response to exchange rate changes (devaluation). Hence, the effects of an exchange rate devaluation in a market with foreign exchange rationing are very different from the effects of a devaluation in an unrestricted foreign exchange market.

In an unrestricted market for foreign exchange (Figure 2), the (real) exchange rate adjusts so that supply of foreign exchange from exports (and current account transfers) (X0) plus net foreign exchange capital inflows (Trade Deficit 0) equals demand for foreign exchange from imports (M0). In such an unrestricted market, a (real) exchange rate depreciation (from ER0 to ER1) tends to increase supply of exports and reduce demand for imports, lowering the trade (current account) deficit (to Trade Deficit 1). In other words, the nominal exchange rate devaluation does its intended effect of reducing the deficit through reduced absorption and increased export supply.

In a restricted or rationed market for foreign exchange, however (Figure 3), changes in the (real) exchange rate need not result in a reduction in imports. This is because, in a ration regime, the demand for foreign exchange for imports (M0) at the official exchange rate (ER0) exceeds total supply of foreign exchange (equal to export (and current account transfer) earnings plus the available foreign exchange from capital inflows and reserve drawdown (M2-X0)). This results in an unmet demand for foreign exchange (M2-M0) at the official exchange rate (ER0). A parallel market for foreign exchange will tend to develop with an exchange rate (ERpar) such that total demand for foreign exchange at this exchange rate (M2) equals total supply.

Figure 2: Impacts of a Devaluation in an Unrestricted Market for Foreign Exchange

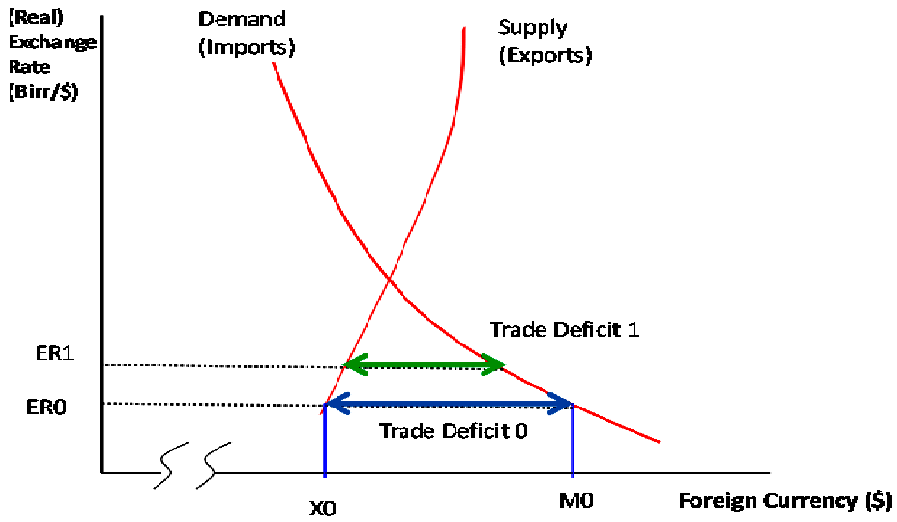
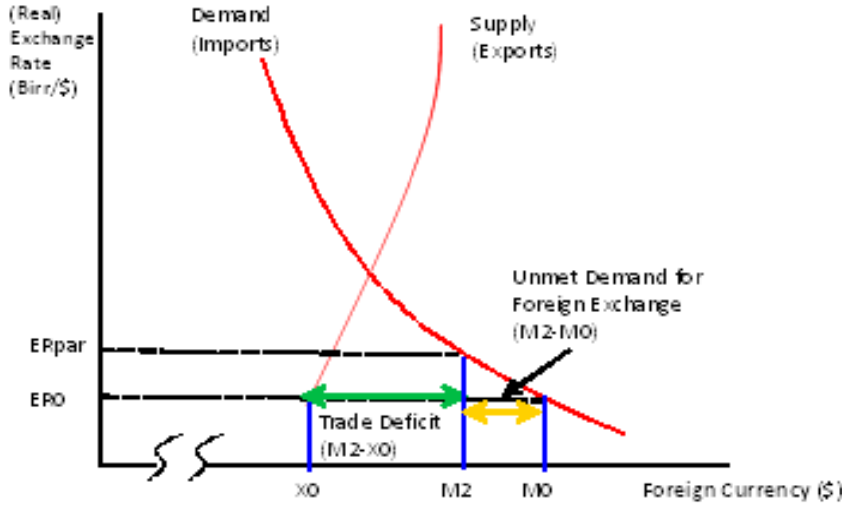


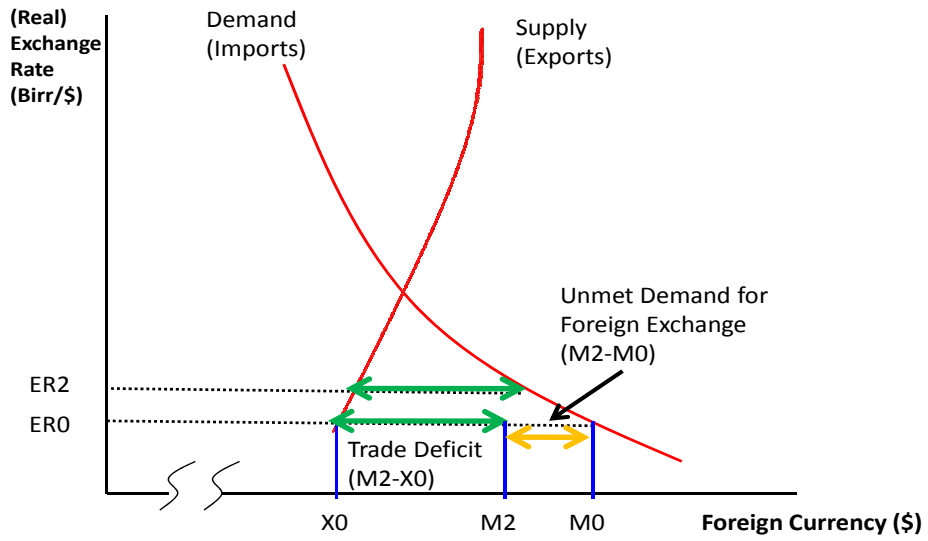
Figure 3: Demand and Supply of Foreign Exchange (Restricted Market)



In this case, (which is the current situation in Ethiopia), a small devaluation will provide additional incentives for exports. However, import demand at that new exchange rate may still be in excess of available foreign exchange, so that foreign exchange rations will still be binding. In this case, the parallel market exchange rate would remain unchanged, as would the market price of imports. Even those importers that obtain the foreign exchange at the low official rate through rations would still sell at the higher rate.[8]

Only if the devaluation is large (i.e. greater than ER2 in Figure 4) will it reduce import demand and increase export supply enough so that the gap between foreign exchange demand and supply is eliminated, the trade deficit is reduced, and imports fall to less than the quota amount.

Figure 4: Impacts of a Devaluation in a Restricted Foreign Exchange Market



[8] In fact, the only instance that the depreciation will have an impact on prices is on those items whose import and supply are government controlled, and for which the government then passes on the higher cost to purchasers.

4. Economy-wide Implications of Rationing of Foreign Exchange

To assess, the economy-wide implications of rationing of foreign exchange, including implications for income and consumption of poor households, we utilize a CGE model of the Ethiopian economy to examine two broad policies:1) the surge in investment, public transfers and foreign capital inflows between 2004/05 and March 2008, and 2) strategies in response to the subsequent decline in foreign capital inflows: import rationing (the policy actually adopted) and an alternative strategy (a significant depreciation of the real exchange rate).

The base data is the EDRI/IDS 2005/06 Ethiopia Social Accounting Matrix, a consistent macro- to micro- accounting framework that is based on Ethiopia's national accounts, the 2004/05 Household Income, Consumption and Expenditure Survey (HICES) and other data.

The CGE model used here is based on those of Dervis, deMelo and Robinson (1982) and Lofgren et al. (2001). Value added in production is modeled using constant elasticity of substitution (CES) production functions of factor inputs (land, livestock capital, various types of labor and non-agricultural capital). Intermediate inputs into production are determined as fixed shares of the quantity of output. Imported goods are assumed to be imperfect substitutes for domestically produced goods; likewise, exported goods are imperfect substitutes for domestically produced and consumed goods. Incomes of the various factors are allocated to households and other institutions on the basis of factor endowments reflected in the factor payment shares in the base SAM. Household consumption is modeled using a Linear Expenditure System (LES) specification.

In the simulations below, non-agricultural capital is fixed by sector, as is agricultural land. Labor is free to move across sectors, but total labor supply is exogenous and the wage rate adjusts to balance supply and demand for labor. We adopt a savings-driven investment closure with marginal propensities to save of all households fixed and the quantity of investment adjusting, so that total savings in the economy is equal to the value of total investment. In simulations 1, the nominal exchange rate is fixed at its base level; foreign savings is also exogenous, and the level of prices of non-tradable goods (and thus the real exchange rate, equal to the ratio of the

nominal exchange rate to the domestic price index), adjusts to bring about equilibrium in the market for foreign exchange. In simulation 2 (foreign exchange rationing), both the domestic price level and the nominal exchange rate are fixed (thereby fixing the real exchange rate). The premium on foreign exchange for imports is modeled using an implicit tariff for all imports that adds to the cost of the foreign exchange. Rents, equivalent to the implicit tariff times the domestic value of imports evaluated at the official exchange rate, are distributed to institutions in fixed shares.[9] In Simulation 3, in which there is no foreign exchange rationing, the domestic price level is again fixed, but the nominal (and real) exchange rates adjust to bring about equilibrium in the foreign exchange market.[10]

Simulation 1: Implications of Increased Capital Inflows and Investment

In simulation 1, we model the effects of the policies of increased investment from 2004/05 through March 2008 when for the most part, foreign capital inflows were not a major constraint for development plans. Historically, the surge in investment derived from two sources: increased private transfers (including workers' remittances) and expansion of domestic credit (and foreign borrowing to meet the resulting increase in demand for foreign exchange). Here, we model the domestic credit – driven increase in investment through an increase in foreign savings that increases the total pool of savings (enabling more investment) and accommodates the increase in demand for foreign exchange for investment (and other resulting demand). Specifically, simulation 1 shows the effects of the increase in investment consistent with an increase in foreign savings inflows equivalent to 20 percent of the value of total imports in the base.

The simulated foreign savings increase approximates the increase in foreign financing between 2005/06 and 2007/08. Note that just between 2006/07 and 2007/08, the current deficit plus public transfers rose by $602 million (equal to 12% of the previous year's merchandise imports), from $2.19 billion to $2.79 billion.

[9] See Annex 1 for details on the estimation of the distribution of rents. See also Condon, Robinson and Urata (1985) for an early discussion of rents from foreign exchange rationing, and Dorosh and Sahn (2000) for a similar treatment of rents in a CGE modeling framework in other sub-Saharan African countries.

[10] Annex Tables 2 and 3 present the model variables and equations. See Dorosh and Thurlow (2009) for details of a slightly different version of the Ethiopia CGE model.

In the simulation, the increased inflow of foreign savings augments total savings and permits an increase in investment spending. To the extent that these funds are spent in the domestic economy, demand for non-tradable goods and their prices tend to rise. Prices of tradable goods, which are tied to world prices by a fixed nominal exchange rate, remain unchanged. Overall, the average price of non-tradable goods rises and the real exchange rate (approximated by the nominal exchange rate divided by a price of non-tradable goods) falls (appreciates) by 21.5 percent (Table 3). This leads to higher incomes and higher investment in the short-run and (implicitly) higher overall growth in the medium-run, at a cost, however, of increased foreign debt.

Table 3: Simulation 1: Increased Foreign Capital Inflows and Total Investment

	Base (bn 2005/06 Birr)	Increase in Foreign Savings (% change)
Real GDP	128.6	0.0%
Absorption	158.8	5.9%
Consumption	114.8	6.1%
Investment	28.2	8.5%
Government	15.9	0.0%
Exports	16.8	-32.6%
Imports	47.0	8.4%
Real Exchange Rate	1.0	-21.5%
Nominal Exchange Rate	100.0	0.0%
CPI	100.0	21.8%
Real HH Incomes		
Rural Poor	21.1	4.8%
Rural Non-Poor	66.0	6.1%
Urban Poor	4.3	4.9%
Urban Non-Poor	23.4	7.5%
Total	**114.8**	**6.1%**

Source: Ethiopia CGE model simulations.

The appreciation of the real exchange rate lowers the domestic prices of exportable goods, inducing a decline in production of major export sectors and a fall in total exports by 32.6 percent. Non-tradable sectors, particular construction, which also benefits from the 8.5 percent in total investment demand, expand (Table 4). The decline in incentives for tradable goods production (the real exchange rate appreciation) is particularly serious since efficient production of tradables (substituting for imports or increasing exports) has been the path for sustained

economic growth in successful developing countries. (In fact, China's macro-economic policies have been designed to maintain an undervalued currency (i.e. to depreciate the real exchange rate relative to its equilibrium value) in order to promote export-led growth.)

The expansion in the economy increases returns to the relatively scare factors of production (capital and land) more than returns to labor. Thus, non-poor households, who own a greater share of capital and land, gain more than poor households in percentage terms. Nonetheless, all household incomes rise, by an overall average of 6.1 percent. This rise in simulated real household incomes reflects the historical rise in real incomes from 2004/05 to late 2007, a period marked by increased foreign exchange inflows and real exchange rate appreciation.

Table 4: Simulation 1: Increased Foreign Capital Inflows and Total Investment: Sectoral Results

	Base (bn 2005/06 Birr)	Increase in Foreign Savings (% change)
Agriculture	53.0	-0.3%
Cereals	16.9	1.8%
Export Crops	9.0	-7.4%
Other Crops	9.5	1.0%
Livestock	17.6	0.6%
Industry	14.5	0.8%
Services	54.8	-0.2%
Total Value Added	122.2	-0.1%

Source: Ethiopia CGE model simulations.

Note, however, that these simulations show the results of a foreign savings inflow in a comparative static framework, essentially showing the economy-wide effects of the shock relative to the base. They do not show the effects of alternative growth paths of the Ethiopian economy over the period. This would require simulating the effects of changes in investment on future levels of capital stock, as well as the effects of increases in total factor productivity in each sector, and the effects of changes in world prices, government spending, and other exogenous variables over time.[11]

[11] In this comparative static model, increases in investment do not add to the current period's capital stock. Moreover, since both labor supply and total capital are fixed, real GDP changes little in these simulations.

Simulations 2 and 3: Implications of Foreign Exchange Rationing

Simulations 2 and 3 illustrate the implications of foreign exchange rationing. In both simulations 2 and 3, foreign savings is reduced by 10 percent of base year's total imports. In simulation 2, foreign exchange for imports is rationed (the policy effectively adopted in March 2008) so that the nominal (and real) exchange rates do not change. In simulation 3, the nominal and real exchange rates are allowed to depreciate in response to the reduction in foreign savings.

In Simulation 2, the decline in foreign savings forces a 10.0 percent reduction in imports. With a smaller pool of total savings, investment falls as well, by 16.6 percent (Table 5). Large rents are created, however, equaling 25.6 billion Birr, (3.0 billion dollars at the 2005/06 average exchange rate of 8.68 Birr/US dollar), with an implicit tariff on imports of 61 percent. These rents accrue mainly to those who have access to foreign exchange for imports.

Table 5: Effects of a Decline in Foreign Savings with and without Import Rationing

	Base (bn 2005/06 Birr)	Simulation 2 Reduced Foreign Savings with Import Rationing (% change)	Simulation 3 Reduced Foreign Savings with no Import Rationing (% change)	Simulation 3 relative to Simulation 2 (% change)
Real GDP	128.6	-1.2%	-0.5%	0.7%
Absorption	158.8	-3.9%	-3.3%	0.6%
Consumption	114.8	-2.6%	-3.2%	-0.6%
Investment	28.2	-12.9%	-5.6%	8.4%
Government	15.9	2.6%	-0.5%	-3.0%
Exports	16.8	-0.2%	16.7%	16.9%
Imports	47.0	-10.1%	-4.1%	6.7%
Real Exchange Rate	1.0	0.0%	11.8%	11.8%
Nominal Exchange Rate	100.0	0.0%	11.8%	11.8%
CPI	100.0	0.0%	2.1%	2.1%
Real HH Incomes				
Rural Poor	21.1	-5.3%	-3.2%	2.2%
Rural Non-Poor	66.0	-8.4%	-3.2%	5.7%
Urban Poor	4.3	-5.9%	-2.1%	4.0%
Urban Non-Poor	23.4	16.9%	-3.4%	-17.4%
Total	114.8	-2.6%	-3.2%	-0.6%

Source: Ethiopia CGE model simulations.

In Simulation 3, foreign savings decline, but since there is no foreign exchange rationing; the real exchange rate depreciates by 11.8 percent. This depreciation spurs the export sector, leading to a 16.7 percent increase in exports and generating additional foreign exchange so that imports fall by only 4.1 percent. Imports are thus 6.7 percent higher than in the rationing scenario (simulation 2). Moreover, real GDP falls by only 0.5 percent (and so is 0.7 percent higher than in simulation 2). The export crop sector expands most in this scenario (by 3.2 percent; Table 6), as it benefits from the real exchange rate depreciation.

Except for the households receiving rents from foreign exchange rationing, household incomes are higher in the no rationing scenario, as compared to the import rationing scenario. In the rationing scenario (Simulation 2), the average income of the urban non-poor increases by 16.9 percent (Table 5). Incomes of other household groups fall, however, as overall economic activity falls (real GDP declines by 1.2 percent). Declines in other household group incomes range from 5.3 and 5.9 percent for the rural and urban poor, respectively, to 8.4 percent for the rural non-poor.

Table 6: Effects of a Decline in Foreign Savings with and without Import Rationing (Sectoral Results)

	Base (bn 2005/06 Birr)	Simulation 2 Reduced Foreign Savings with Import Rationing (% change)	Simulation 3 Reduced Foreign Savings with no Import Rationing (% change)	Simulation 3 relative to Simulation 2 (% change)
Agriculture	53.0	0.0%	0.1%	0.1%
Cereals	16.9	-0.9%	-1.1%	-0.2%
Export Crops	9.0	0.5%	3.2%	2.7%
Other Crops	9.5	-1.3%	-0.5%	0.8%
Livestock	17.6	1.2%	-0.1%	-1.4%
Industry	14.5	-1.4%	-0.4%	0.9%
Services	54.8	0.1%	0.0%	-0.1%
Total Value Added	122.2	-0.1%	0.0%	0.1%

Source: Ethiopia CGE model simulations.

The declines in the incomes of household groups other than the urban non-poor are smaller in the no import rationing scenario (Simulation 3). For these households, average real incomes decline by 2.1 to 3.2 percent. Compared with the rationing scenario, incomes of the rural non-poor rise by 5.7 percent, in large part because of

the improved performance of the export crop sector. The real incomes of the rural and urban poor also improve, by 2.2 and 4.0 percent, respectively, reflecting increased economic activity (the 0.7 percent increase in real GDP). Although real household incomes of the urban non-poor fall by only 3.4 percent relative to the base scenario, the fall relative to simulation is very large (-17.4 percent), because of the loss of rents from foreign exchange rationing.

Sensitivity analysis shows that the major results are robust with respect to changes in the parameters determining export supply and import demand response. Parameters determining the export supply elasticities are inelastic in the base run. Making these parameters even more price inelastic makes little difference to the results. For example, reducing the elasticity of substitution between (fixed) land and labor for export crops from 0.2 to 0.1, reducing the elasticity of substitution between aggregate of factor inputs and intermediate inputs from 0.6 to 0.3, and reducing the elasticity of substitution in the CET function for export crops from 0.4 to 0.2, cuts the gain in export crop output from 2.7 percent with the base parameters to 1.4 percent with the alternative parameters, but increases the real exchange rate difference between simulation 3 and simulation 2 only slightly, from 11.8 percent to 12.6 percent. One reason for the small effect of changes in export parameters on the real exchange rate is that exports earnings are only about one-third the value of imports in the base 2005/06 SAM.

Making import demand parameters more elastic, (by raising the Armington elasticity of substitution between domestically produced and consumed goods, and imported goods from a very low 0.2 in the main simulations to 0.7 for all imported manufactured goods and services), reduces the magnitude of the real exchange rate change needed to bring the external accounts in to equilibrium. Thus, with more elastic import demand, the real exchange rate depreciation in simulation 3 is only 11.7 percent, as compared to 12.6 percent with inelastic export supply and very inelastic import demand. These minor changes in magnitude of the effect do not change the main results, however: allowing the real exchange rate to depreciate produces better distributional and efficiency outcomes that does import rationing.

Table 7: Effects of Real Exchange Rate Depreciation vis a vis Foreign Exchange Rationing: Sensitivity Analysis

	Base Parameters (% change)	Inelastic Export Supply (% change)	Inelastic Export Supply and More Elastic Import Demand (% change)
Real GDP	0.7%	0.7%	0.5%
Absorption	0.6%	0.6%	0.5%
Consumption	-0.6%	-0.5%	-0.4%
Investment	8.4%	8.3%	5.8%
Government	-3.0%	-3.0%	-1.8%
Exports	16.9%	16.7%	16.7%
Imports	6.7%	6.7%	6.6%
Real Exchange Rate	11.8%	12.6%	11.7%
Nominal Exchange Rate	11.8%	12.6%	11.7%
CPI	2.1%	2.2%	1.9%
Real HH Incomes			
Rural Poor	2.2%	2.0%	1.9%
Rural Non-Poor	5.7%	5.9%	4.4%
Urban Poor	4.0%	4.4%	2.6%
Urban Non-Poor	-17.4%	-17.3%	-13.7%
Total	-0.6%	-0.5%	-0.4%
Agriculture	0.1%	0.1%	0.0%
Cereals	-0.2%	0.1%	0.0%
Export Crops	2.7%	1.4%	1.3%
Other Crops	0.8%	1.1%	0.8%
Livestock	-1.4%	-1.1%	-1.0%
Industry	0.9%	1.1%	0.5%
Services	-0.1%	-0.1%	-0.1%
Total Value Added	0.1%	0.1%	0.1%

Notes: This table shows the percentage difference between simulation 3 (reduced foreign savings with no import rationing) and simulation 2 (reduced foreign savings with import rationing) using alternative sets of parameters that determine overall export supply import demand responses. See text.

5. Conclusions

The quantitative estimates presented in this paper suggest that there are substantial efficiency and distributional effects of foreign exchange rationing. Foreign exchange controls result in the creation of large rents that likely accrue mainly to non-poor households.[12] At the same time, foreign exchange controls reduce economic

[12] See Sahn, Dorosh and Younger (1997) and Dorosh and Sahn (2000) also show major adverse consequences of foreign exchange rationing for sub-Saharan Africa countries in the 1980s and early 1990s.

efficiency so that real incomes from factors of production (land, capital and labor) decline, as do overall household incomes (except for those who gain large rents). Moreover, foreign exchange controls inhibit depreciation of the real exchange rate, and thus slow or prevent reversal of the real exchange rate appreciation between 2004/05 and 2007/08, which has resulted in major price disincentives for exports.

The modeling results presented here are not meant as definitive estimates, but rather as indicators of the broad magnitudes of the effect of the policies simulated. Further efforts are needed to refine the model simulations so as to include the effects of changes in world prices and to assess dynamic effects of shocks and policies on growth and income distribution. Dynamic simulations of alternative investment strategies, including greater investment in tradable goods sectors, would also be helpful in assessing medium-term growth options.

Nonetheless, the broad policy implications of this analysis are clear. There are substantial costs to both foreign exchange rationing and real exchange rate appreciation in terms of lower investment, reduced incentives for production of tradables, lower levels of foreign trade (and opportunities for the acquisition of technology that can enhance future growth), as well as more unequal income distribution (large rents accruing to the non-poor).

Policy reforms need not involve full liberalization of the foreign exchange market, however. Various versions of managed floats and controls in foreign capital markets exist that can gradually reduce economic rents, improve incentives for exports and increase overall economy efficiency. Indeed, policies since late 2008 have effectively reduced the earlier appreciation of the real exchange rate. To recover more fully from the effects of the adverse external price and capital inflow shocks of 2007 and 2008, and to sustain the rapid pro-poor growth of recent years, though, further measures to restore real price incentives to exports, and reduce rents and economic inefficiencies arising from import rationing should be considered.

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Annex 1: Estimation of Distribution of Rents

The distribution of rents is based on the structure of the use of imports by commodity group in the 2004-05 SAM and assumptions regarding the structure of rents by these commodity groups.

For wheat, it is assumed that urban poor households acquire imported wheat through the direct government sales and sales through cooperatives (41 percent of total wheat imports, Table 4) at a price based on the official exchange rate. The remaining 59 percent of the value of rents from imported wheat are assumed to accrue to the urban non-poor.

Petroleum rents are allocated on the basis of total uses (final consumption, intermediate demand and investment demand), where rents from use of petroleum in trade and transport accrue to households and government according to their shares in total consumption and investment demand for all goods and services (with the share of investment demand in total demand allocated to the government). Rents from petroleum used in construction and other activities are assumed to be split evenly between the urban non-poor and the government. Total rents from petroleum thus accrue mainly to the urban non-poor (39%), the government (35%) and rural non-poor (19%).

Rents arising from petroleum use in trade and transport activities are allocated on the basis of shares in total consumption and investment expenditures, with government assumed to receive rents from investment. Thus, total rents from petroleum us in trade and transport activities are allocated mainly to rural non-poor households (46%), urban non-poor (26%), government (10%), and rural poor (15%).

For all other commodities, rents are initially allocated as 50% to the urban non-poor and 50% to the government.

In the final step, all rents initially allocated to government are distributed to households according to their shares in total consumption expenditures. The outcome of these calculations is that 56% of total rents accrue to urban non-poor

households, 30% to rural non-poor households, 10% to rural poor households and 4 percent to urban poor households.

Annex Table A1: Assumed Distribution of Rents by Institution and Commodity

	Imports	Share	Hrural-P	Hrural-np	Hurba-p	Hurban-np	Govern	Total
Ctef	0.00	0.0%				50%	50%	100.0%
Cwheat	1.64	3.5%			41%	59%		100.0%
Cmaize	0.00	0.0%				50%	50%	100.0%
Cbarsor	0.00	0.0%				50%	50%	100.0%
Cagex	0.04	0.1%				50%	50%	100.0%
Censet	0.00	0.0%				50%	50%	100.0%
Cothrag	0.53	1.1%				50%	50%	100.0%
Clivstk	0.08	0.2%				50%	50%	100.0%
Chome1	0.00	0.0%				50%	50%	100.0%
Chome2	0.00	0.0%				50%	50%	100.0%
Cmilling	0.09	0.2%				50%	50%	100.0%
Cfood	1.57	3.3%				50%	50%	100.0%
Cchem	5.78	12.3%				50%	50%	100.0%
Celect	0.00	0.0%				50%	50%	100.0%
Cwater	0.00	0.0%				50%	50%	100.0%
Cptrl	5.73	12.2%	5%	19%	2%	42%	32%	100.0%
Ci-mfg	4.34	9.2%				50%	50%	100.0%
Cf-mfg	15.82	33.6%				50%	50%	100.0%
Cconst	0.00	0.0%				50%	50%	100.0%
Ctrd-trn	8.14	17.3%	15%	46%	3%	26%	10%	100.0%
Cgov	0.08	0.2%					100%	100.0%
Cosvc	3.18	6.8%				50%	50%	100.0%
SubTotal	47.01	100.0%	3.2%	10.3%	2.2%	45.1%	39.2%	100.0%
Public Rents			6.4%	20.1%	1.3%	11.4%		39.2%
Total			9.6%	30.4%	3.5%	56.5%		100.0%

Source: EDRI 2005/06 SAM and authors' estimates.

***Annex Table A2*: CGE Model Sets, Parameters and Variables**

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CMN(\subset C)$	Commodities not in *CM*
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CT(\subset C)$	Transaction service commodities
$c \in C$	Commodities	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$f \in F$	Factors
$c \in CDN(\subset C)$	Commodities not in *CD*	$i \in INS$	Institutions (domestic and rest of world)
$c \in CE(\subset C)$	Exported commodities	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CEN(\subset C)$	Commodities not in *CE*	$i \in INSDNG(\subset IN$	Domestic non-government institutions
$c \in CM(\subset C)$	Aggregate imported commodities	$h \in H(\subset INSDNC$	Households
Parameters			
$cwts_c$	Weight of commodity c in the CPI	$qdst_c$	Quantity of stock change
$dwts_c$	Weight of commodity c in the producer price index	$\overline{qg}_c$	Base-year quantity of government demand
ica_{ca}	Quantity of c as intermediate input per unit of activity a	$\overline{qinv}_c$	Base-year quantity of private investment demand
$icd_{cc'}$	Quantity of commodity c as trade input per unit of c' produced and sold domestically	$shif_{if}$	Share for domestic institution i in income of factor f

***Annex Table A2* (continued): CGE Model Sets, Parameters and Variables**

Symbol	Explanation	Symbol	Explanation
$ice_{cc'}$	Quantity of commodity c as trade input per exported unit of c'	$shii_{ii'}$	Share of net income of i' to i (i' ∈ INSDNG'; i ∈ INSDNG)
$icm_{cc'}$	Quantity of commodity c as trade input per imported unit of c'	ta_a	Tax rate for activity a
$inta_a$	Quantity of aggregate intermediate input per activity unit	$\overline{tins_i}$	Exogenous direct tax rate for domestic institution i
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps_i}$	Base savings rate for domestic institution i	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tq_c	Rate of sales tax
pwe_c	Export price (foreign currency)	$trnsfr_{i\,f}$	Transfer from factor f to institution i
pwm_c	Import price (foreign currency)		
Greek Symbols			
α_a^a	Efficiency parameter in the CES activity function	δ_{cr}^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity c for household h
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity a

***Annex Table A2* (continued): CGE Model Sets, Parameters and Variables**

Symbol	Explanation	Symbol	Explanation
Greek Symbols			
α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
β^a	Capital sectoral mobility factor	ρ_a^{va}	CES value-added function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^{ac}	Domestic commodity aggregation function exponent
δ_a^a	CES activity function share parameter	ρ_c^q	Armington function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^t	CET function exponent
δ_{cr}^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
υ_f	Capital depreciation rate	QF_{fa}	Quantity demanded of factor f
Exogenous Variables			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor f in activity a
$\overline{IADJ}$	Investment adjustment factor		

Endogenous Variables			
AWF_{ft}^{a}	Average capital rental rate in time period t	QG_c	Government consumption demand for commodity
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QH_{ch}	Quantity consumed of commodity c by household h
DPI	Producer price index for domestically marketed output	QHA_{ach}	Quantity of household home consumption of commodity c from activity a for household h
EG	Government expenditures	$QINTA_a$	Quantity of aggregate intermediate input
EH_h	Consumption spending for household	$QINT_{ca}$	Quantity of commodity c as intermediate input to activity a
EXR	Exchange rate (LCU per unit of FCU)	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_{cr}	Quantity of imports of commodity c
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PA_a	Activity price (unit gross revenue)	QT_c	Quantity of commodity demanded as trade input
PDD_c	Demand price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PDS_c	Supply price for commodity produced and sold domestically	QX_c	Aggregated quantity of domestic output of commodity
PE_{cr}	Export price (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity c from activity a

Endogenous Variables continued

$PINTA_a$	Aggregate intermediate input price for activity a	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period t	$TABS$	Total nominal absorption
PM_{cr}	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution i (i ∈ INSDNG)
PQ_c	Composite commodity price	$TRII_{ii'}$	Transfers from institution i' to i (both in the set INSDNG)
PVA_a	Value-added price (factor income per unit of activity)	WF_f	Average price of factor
PX_c	Aggregate producer price for commodity	YF_f	Income of factor f
$PXAC_{ac}$	Producer price of commodity c for activity a	YG	Government revenue
QA_a	Quantity (level) of activity	YI_i	Income of domestic non-government institution
QD_c	Quantity sold domestically of domestic output	YIF_{if}	Income to domestic institution i from factor f
QE_{cr}	Quantity of exports	ΔK^a_{fat}	Quantity of new capital by activity a for time period t

Annex Table A3: **CGE Model Equations**

Production and Price Equations	
$QINT_{ca} = ica_{ca} \cdot QINTA_a$	(1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}-1}$	(4)
$QF_{fa} = \alpha_{fa}^{van} \cdot \left(\sum_{f' \in F} \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}} \right)^{-\frac{1}{\rho_{fa}^{van}}}$	(5)
$W_{f'} \cdot WFDIST_{f'a} = W_f \cdot WFDIST_{fa} \cdot QF_{fa} \cdot \left(\sum_{f'' \in F} \delta_{ff''a}^{van} \cdot QF_{f''a}^{-\rho_{fa}^{van}} \right)^{-1} \cdot \delta_{ff'a}^{van} \cdot QF_{f'a}^{-\rho_{fa}^{van}-1}$	(6)
$QVA_a = iva_a \cdot QA_a$	(7)
$QINTA_a = inta_a \cdot QA_a$	(8)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(9)
$QXAC_{ac} = \theta_{ac} \cdot QA_a$	(10)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(11)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(12)
$PXAC_{ac} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{ac}^{ac} \cdot QXAC_{ac}^{-\rho_c^{ac}-1}$	(13)
$PE_{cr} = pwe_{cr} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(14)

Annex Table A3 (continued): **CGE Model Equations**

$$QX_c = \alpha_c^t \cdot \left(\sum_r \delta_{cr}^t \cdot QE_{cr}^{\rho_c^t} + (1 - \sum_r \delta_{cr}^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \quad (15)$$

$$\frac{QE_{cr}}{QD_c} = \left(\frac{PE_{cr}}{PDS_c} \cdot \frac{1 - \sum_r \delta_{cr}^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \quad (16)$$

$$QX_c = QD_c + \sum_r QE_{cr} \quad (17)$$

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + \sum_r PE_{cr} \cdot QE_{cr} \quad (18)$$

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \quad (19)$$

$$PM_{cr} = pwm_{cr} \cdot (1 + tm_{cr}) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'c} \quad (20)$$

$$QQ_c = \alpha_c^q \cdot \left(\sum_r \delta_{cr}^q \cdot QM_{cr}^{-\rho_c^q} + (1 - \sum_r \delta_{cr}^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \quad (21)$$

$$\frac{QM_{cr}}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \sum_r \delta_{cr}^q} \right)^{\frac{1}{1+\rho_c^q}} \quad (22)$$

$$QQ_c = QD_c + \sum_r QM_{cr} \quad (23)$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + \sum_r PM_{cr} \cdot QM_{cr} \quad (24)$$

$$QT_c = \sum_{c' \in C'} \left(icm_{cc'} \cdot QM_{c'} + ice_{cc'} \cdot QE_{c'} + icd_{cc'} \cdot QD_{c'} \right) \quad (25)$$

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \quad (26)$$

$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c \quad (27)$$

Annex Table A3 (continued): **CGE Model Equations**

Institutional Incomes and Domestic Demand Equations	
$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{f\,a} \cdot QF_{f\,a}$	(28)
$YIF_{i\,f} = shif_{i\,f} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right]$	(29)
$YI_i = \sum_{f \in F} YIF_{i\,f} + \sum_{i' \in INSDNG'} TRII_{i\,i'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$	(30)
$TRII_{i\,i'} = shii_{i\,i'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'}$	(31)
$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{i\,h} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h$	(32)
$PQ_c \cdot QH_{c\,h} = PQ_c \cdot \gamma^m_{ch} + \beta^m_{ch} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma^m_{c'h} \right)$	(33)
$QINV_c = IADJ \cdot \overline{qinv}_c$	(34)
$QG_c = \overline{GADJ} \cdot \overline{qg}_c$	(35)
$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$	(36)
System Constraints and Macroeconomic Closures	
$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR$	(37)
$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c$	(38)
$\sum_{a \in A} QF_{f\,a} = QFS_f$	(39)
$YG = EG + GSAV$	(40)
$\sum_{r\,c \in CMNR} pwm_{cr} \cdot QM_{cr} + \sum_{f \in F} trnsfr_{row\,f} = \sum_{r\,c \in CENR} pwe_{cr} \cdot QE_{cr} + \sum_{i \in INSD} trnsfr_{i\,row} + FSA$	(41)
$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qds$	(42)

$$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right) \tag{43}$$

Capital Accumulation and Allocation Equations

$$AWF_{f\,t}^{a} = \sum_{a}\left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}}\right)\cdot WF_{f\,t}\cdot WFDIST_{f\,a\,t}\right] \tag{44}$$

$$\eta_{f\,a\,t}^{a} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}}\right)\cdot\left(\beta^{a}\cdot\left(\frac{WF_{f,t}\cdot WFDIST_{f\,a\,t}}{AWF_{f\,t}^{a}} - 1\right) + 1\right) \tag{45}$$

$$\Delta K_{f\,a\,t}^{a} = \eta_{f\,a\,t}^{a}\cdot\left(\frac{\sum_{c} PQ_{c\,t}\cdot QINV_{c\,t}}{PK_{f\,t}}\right) \tag{46}$$

$$PK_{f\,t} = \sum_{c} PQ_{c\,t}\cdot\frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}} \tag{47}$$

$$QF_{f\,a\,t+1} = QF_{f\,a\,t}\cdot\left(1 + \frac{\Delta K_{f\,a\,t}^{a}}{QF_{f\,a\,t}} - \upsilon_f\right) \tag{48}$$

$$QFS_{f\,t+1} = QFS_{f\,t}\cdot\left(1 + \frac{\sum_{a}\Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f\right) \tag{49}$$

SPATIAL PRICE DYNAMICS AND PRICING CONDUCT OF WHEAT MARKETS IN ETHIOPIA[1]

Degye Goshu[2], Admasu Shibru[3], and Belay Kassa[4]

Abstract

This paper has examined the spatial integration, price dynamics, and pricing behavior of wheat markets in Ethiopia using 72 months retail price series (July 2001-June 2007) and cross-section data of structural determinants of spatial integration. Dynamic measures of spatial integration including long-run multipliers, speed of spatial price adjustment, and composite index were estimated to measure the magnitude, speed, and extent of spatial linkages and to identify the relative importance and pricing conduct in these markets. The common assertion that Addis Ababa is a central market dictating commodity price formation process in Ethiopia was disproved. Nazreth wheat market was found to be the center of price discovery in the country by dictating price formation in supply markets. The three hypothesized oligopolistic pricing behavior of wheat markets— spatial price discrimination, instantaneous and cooperative pricing, and perfect price matching — were tested. The two hypotheses that wheat markets exercise spatial price discrimination and cooperative pricing were rejected. However, the hypothesis of spatial price discrimination was accepted for some markets trading with Addis Ababa and Nazreth. This is verified to be the result of price discrimination exercised in Addis Ababa and the response of supply markets against the conduct in the

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destination markets. Supply markets with alternative market outlets were trying to establish short-run market independence depending on the pricing conduct prevalent in the destination markets while those without alternative market outlets were victims of the pricing behavior. This is an indication of inefficient pricing system prevalent in the wheat marketing system. Structural determinants of spatial market integration including inter-market road distance, road density, dissimilarity in per capita wheat production, and dissimilarity in population density were estimated and tested for their possible effect on the level, speed and extent of market integration to identify alternative market development interventions. Except for population density, all the selected factors of market integration were found to significantly determine market integration in Ethiopia. The spatial integration of Ethiopian wheat markets was found to be generally low in magnitude and sluggish in speed because of lack of flexibility and responsiveness of the marketing system.

Key words: Price dynamics, long-run multiplier, speed of adjustment, composite index, pricing behavior.

1. Introduction

A priori economic theory indicates that spatially efficient markets increase supply and decrease price of goods and services in deficit areas, and decrease supply and increase price of goods and services in surplus areas. This increases the benefit of both producers in surplus areas and consumers in deficit areas to generate a positive net effect on social welfare which is a very important social function of spatial arbitrage (Tschirley, 1995). Moreover, prices in efficient markets are relatively stable and they can be forecasted. Periodic gluts and shortages are indicative of spatial inefficiency of markets.

The Ethiopian wheat production is not evenly distributed geographically. According to the survey conducted by Central Statistical Agency (CSA), about 95% of the national wheat production is produced in the regional states of Oromia, Amhara, and Southern Nations Nationalities and Peoples State (SNNPS). Most parts of the localities in the country are supplied through spatial arbitrage from these producing

areas. Such distribution of goods can be economical if spatial arbitrage is efficient. Market efficiency is the distribution of goods and services related not only with the market performance but also with the problem of food insecurity. Without efficient spatial arbitrage of food products, food shortage in an area cannot be prevented from causing famine in deficit areas. Spatial food insecurity can be prevented before triggering famine if spatial arbitrage is efficient to distribute produces from surplus areas to deficit areas (Webb *et al.,* 1992).

Efficient markets are integrated spatially, temporally and vertically across different forms of products. The critical importance of spatial arbitrage calls for the need to know the extent of spatial market integration, pricing conduct and adequacy of marketing infrastructural facilities. This enables to fix intervention measures for a better market performance and prevention of food shortages in deficit areas. There is no clear and sufficient understanding about the strength and speed of spatial market integration and price dynamics in Ethiopian wheat markets. Ethiopian wheat markets are alleged to be inefficient by various marketing agents such as producers, consumers, grain traders, and the government.

For the majority of grain markets, the dynamics of spatial price adjustment is not estimated to enable cost-effective policy intervention and evaluation of policy effects. Most spatial market integration studies are conducted to estimate cointegration coefficients as measures of the long-run integration of markets. However, cointegration coefficients cannot indicate the actual magnitude and speed of price adjustment, and direction of price causation. The other major problem of spatial market integration studies conducted in Ethiopia is the selection method. Less objective criteria are used to specify the price interdependence between markets so that the models will be miss-specified either by omission of major markets or inclusion of less important markets. This leads to erroneous conclusions. However, there are some impacting studies conducted on the Ethiopian commodity marketing system after liberalization of the marketing system in Ethiopia which enabled to generate some relevant policy intervention measures in the country. The most important initiative was the Grain Market Research Project (GMRP) conducted just after liberalization of the markets which resulted in production of a number of working papers on grain markets including Asfaw and Jayne (1997) and Gebremeskel

et al (1998). The latest studies assumed to have significant policy and intervention impact include the papers by Eleni (2001), Kindie (2007), and Kindie *et al* (2006).
Because of these limited research efforts, there is still a wider gap to fill the requirement for sufficient empirical evidence on the Ethiopian grain marketing system. There are many markets and commodities not yet addressed properly. Generally, there is lack of sufficient, latest, accurate, reliable, and prompt information about the efficiency of arbitrage in the discovery of wheat prices across markets in Ethiopia. Among other things, the Ethiopian wheat marketing system has problems requiring empirical justification on the extent of price dynamics, pricing conduct, and major factors determining market integration covering major markets and commodities. Accordingly, this study is conducted to generate information and fill some gaps in the price adjustment dynamics, the pricing behavior, and the structural determinants affecting the price adjustment process in wheat markets.

The specific objectives of the study are:

a. to estimate the magnitude, speed and direction of spatial price dynamics of important wheat markets;
b. to identify the pricing conduct of wheat markets; and
c. to identify the factors that determine the integration of the markets and to estimate their impacts on the extent of wheat market integration.

The remaining parts of the paper are organized in four units. The overview of the commodity marketing system in Ethiopia and the research methodology are presented in the second and third units, respectively. Discussion of the results is presented in the fourth unit and the last unit concludes the paper.

2. The Commodity Marketing System in Ethiopia

There have been different studies on commodity market performance conducted in Ethiopia since the commodity market liberalization in 1990. Performance of the marketing system is verified by these studies to suffer from various problems. The most dominant studies are reviewed to highlight the nature of the marketing system, to qualify previous contributions, and to identify the knowledge gap existing in researching the Ethiopian commodity marketing system.

Webb *et al.* (1992) have studied the spatial integration of cereal markets in Ethiopia to detect the spatial efficiency of local markets and their contributions in alleviating food shortage that has occurred because of drought in different geographical locations. The study was conducted in situations of low marketing infrastructure and strictly government controlled trade policy before 1990 (data for 1984-89). That period is expected to be quite different from the 17 years of trade liberalization period. They have used 13 selected regional markets, 3 grain types, and 70 monthly price observations. Most of the markets were found to be segmented from the principal market, (i.e. Nazareth), even within an average distance of 461 kilometers. Few markets were weakly integrated within an average distance of 253 kilometers from the reference market, and the rural markets were almost totally segmented from the respective regional markets. The study used two models of market integration: correlation coefficients and index of market connection (IMC). However, Dercon (1995) has used cointegration technique to analyze market integration in Ethiopia and verified that most market prices were cointegrated with Addis Ababa price, assumed to be the central market.

After grain trade liberalization in Ethiopia, the major breakthrough in grain market efficiency studies are those studies conducted by Grain Market Research Project (GMRP) under the Ministry of Economic Development and Cooperation (MEDAC). This research project has resulted in various working papers and market analysis notes on both input and output markets. Asfaw and Jayne (1997) have analyzed the response of Ethiopian grain markets to market liberalization policy by selecting 11 grain types and eight local markets. Among the eight local markets four of them were wheat markets (one surplus and three deficits). They have used simple price correlation coefficients to estimate the spatial efficiency of these markets using 10 years monthly price data, and 13 months price series to estimate the equilibrium grain prices as a function of seasonality, grain market liberalization policy measures, rainfall, and food aid. The spatial price correlation coefficients for wheat markets were ranging from 8% to 82%. The researchers have concluded that there was spatial efficiency and commented on some of the problems to be resolved for better spatial efficiency. Asfaw and Jayne (1998) again have studied the spatial and the vertical integration of grain markets in Ethiopia. They considered a total of 10 markets (seven surpluses and three deficits) to analyze the spatial wheat price relationships with the Addis Ababa market. In their analysis, they found that grain

prices in the seven markets (78%) were not significantly related with that in Addis Ababa market, which is a contradiction with the results of the first study conducted by them a year before. However, the existence of a real and long-run relationships between grain markets was not indicated since the scope and purpose of the study was vast.

Gebremeskel *et al.* (GMRP, 1998) has studied the market structure, conduct, and performance of markets by giving a special emphasis on the constraints of grain markets in Ethiopia. In their analysis using temporal and spatial price relationships of 11 selected grain markets and three grain types, they have identified the major constraints of Ethiopian grain markets. These constraints include *kella* charges between markets, absence of control on un-licensed merchants, absence of access to transportation service, and market information. Even though their study was not designed to identify and estimate the magnitude and speed of spatial market integration, they have indicated that there were problems and constraints in the spatial market integration

Eleni (2001) has studied the marketing institutions, transaction costs, and social capital in the Ethiopian grain market based on 1996 market survey data and coefficients estimated by another study. Among other things, she identified the pricing conduct behind integrated markets and concluded that they seemed spatially efficient without exhibiting price efficiency. This was due to collusive pricing conduct that was prevalent in urban grain markets. However, there were no estimates of long-run market integration to compare the difference between short-run and long-run integration measures, and to conclude about extent of spatial efficiency in Ethiopian grain markets.

Kindie *et al.* (2006) have analyzed the dynamics of six white wheat markets (Nazreth, Shashemenie, Jimma, Addis Ababa, Dire Dawa, and Mekelle) using vector autoregressive (VAR) model assuming the first three to be surplus and the last three to be deficit markets of wheat. They used the VAR model assumed to be better alternative model to address the simultaneous interaction of markets by identifying markets with common factors for policy intervention. They selected these markets assuming that they were major supply and consumer markets. The monthly wholesale price levels were tested for causality using vector error correction

mechanism (VECM) in which case Nazreth and Shashemenie were found to be price leaders while there was no exclusive price leadership of wheat markets in the country. The common assertion that Addis Ababa is a price leader was not supported by the results. However, the markets were selected by "their importance as a major supply or as a major consumer market" that there is no justified criterion as to why not other major wheat supply markets were not included. The dominance of a market in the general supply or consumption of goods cannot guarantee its dominance in wheat supply or consumption. This method of market selection might have resulted in misspecification of the price interdependence (ignoring very dominant markets and including insignificant markets of wheat). Generally, this study is relatively more empirical than previous studies conducted in Ethiopia and the weak parameter estimates signify the considerations to be taken in sampling of relevant wheat markets to avoid risk of misspecification of price interdependence.

Kindie (2007) has analyzed the spatial equilibrium of wheat markets in Ethiopia by considering one supply (Ambo) and one central market (Addis Ababa) using autoregressive distributive lag (ARDL) approach to estimate the dynamics of price transmission of white wheat between the two markets. Based on the results of the coefficients of the cointegration analysis, he recommended that it is better to use intervention measures in the central market rather than in local markets since stabilization measures in local markets would result in high cost of intervention. The number of markets considered is limited; in which case the pattern of price interdependence between terminal and surplus markets might be different for other markets. Because of the risk of ignoring other important wheat markets, *i.e.* misspecification, the pattern of price interdependence between Ambo and Addis Ababa might not be taken as common factor for other market pairs and it might be difficult to recommend about the point of intervention required. However, this work was a basis for further studies to address more markets and commodities traded in Ethiopia.

3. Methodology

3.1. Data and Sampling Techniques

The specification of price interdependence between markets is determined by the selection of markets in the spatial analysis. The selection of markets is the selection

of both explanatory and dependent variables because we use variables like price information and commodity flows in these markets. If relevant markets are excluded, the results will validate the absence of price interdependence, or less important market will seem dominant. In literature, there is no objective criterion as to how to select all important markets or to exclude all less important markets before estimation. Because of this problem many spatial market integration studies conducted at national level use less objective criteria to select important markets. In the presence of this problem, Asfaw *et al* (1997), Asfaw (1998), Kindie *et al* (2006), and Kindie (2007) have selected their markets of interest by less objective criteria. However, the studies have their useful policy implications on the Ethiopian grain marketing system and are indicative of the caution to be taken in modeling of price interdependence.

In this study, a relatively more objective criterion of market selection was proposed and applied. The criteria of per capita wheat production, annual retail price, and distance from the destination market were used in order to avoid specification errors in selection of supply markets. The sample markets were selected using a multi-stage sampling method. First, supply regional states were selected by their annual per capita wheat production potential. Accordingly, two regional states (Oromia and Amhara) were selected and wheat producing zones in these regions were identified by the same criterion. The supply zones (with their per capita wheat production in kilograms per person per annum) were selected to be Bale (118.2), Arsi (109.2), West Shewa (87.6), North Shewa of Amhara Region (73.2), East Shewa (72.9) South West Shewa, East Wellega (40.2), and South Wello (36.5). The markets in these supply zones were, in turn, selected by their (lowest) annual average retail price of wheat in 2005/06 and their (nearest) distance from the destination market.

The major destination markets were automatically selected as deficit (destination) markets. The price and the distance criteria can avoid the selection of distant markets because of their natural tendency of price decrease as the inter-market distance increases. Based on these criteria, the most surplus eight wheat markets were elected. These markets were Adaba, Diksis, Ambo, Debre Birhan, Nazreth, Woliso, Shambu, and Dessie. The destination markets were Addis Ababa and Mekelle, and the markets pairs were constructed based on the presence of wheat stock flow between markets.

Ethiopian wheat markets have many structural deficiencies, in which case, spatial price adjustment is expected to be very sluggish. Price movements or fluctuations across wheat markets are more frequent and observable on monthly basis, than weekly or daily basis, where markets are weakly integrated. If the price dynamics is expected to be sluggish, even if weekly prices are preferable, monthly prices are also applicable. For instance Mendoza and Rosegrant (1995b), Tschirley (1995), Asfaw and Jayne (1997, 1998), Kherallah *et al* (2000), and Kindie *et al* (2007) have used monthly average prices to estimate spatial market integration measures.

The minimum time required to respond to price changes occurred in another markets is, therefore, expected to be at least a month. Reaction time less than a month is considered to be instantaneous. Moreover, price data are readily available on monthly basis for the selected markets justifying that data availability was the main reason to use monthly retail price-series for the study. Monthly retail prices of six years (July 2001-June 2007) and relevant consumer price indices (CPI) were collected for the selected markets from statistical reports of CSA. 720 monthly average retail prices for 10 markets and 72 consumer price indices for food were collected. Data gaps on prices were highly insignificant (only 2.2%). These price data gaps were filled by the average of the prices in the previous and the following months.

The data required to explain the reasons behind the integration of the markets in this paper include inter-market distance, road density, dissimilarity in per capita wheat production (DPCP), dissimilarity in population density (DPD), and supply shocks. They were collected from primary (field surveys) and secondary sources. The time series annual wheat production data indicated the absence of significant wheat production shocks in the areas of the selected markets.

In this empirical study, the spatial market integration is expressed in terms of price interdependence. Price information flow creates commodity flows directly or indirectly to influence commodity prices across markets. However, measures estimated from nominal prices are expected to be spurious and, hence, prices should be transformed to eliminate these spurious relationships. Variable transformation avoids or minimizes problem of multicollinearity, converts a nonstationary time series into stationary, changes nonlinear relationship into linear,

and avoids problem of seasonality and other common macroeconomic factors such as inflation (Tschirley, 1995).

Nominal prices were deflated by the consumer price index (CPI) for food. The weight of white wheat in computing CPI for cereals was high, but its share in computing the general CPI for food was about 4% which is insignificant to affect the deflation (CSA, 2007). Since wheat was the major component to compute CPI for cereals, the appropriate deflator was found to be the CPI for food. To overcome the above estimation problems, monthly real retail price series were transformed to natural logarithms, and the differences of their natural logarithms were multiplied by 100 to avoid scaling problems. The parameters were estimated by percentage real price changes transformed as

$$\Delta P_t = (\ln P_t - \ln P_{t-1}) \times 100 \qquad \textbf{(1)}$$

Where $\Delta P_t =$ percentage real price change of white wheat at time t; $P_t =$ real retail price of white wheat; $\ln =$ natural logarithm; $P_{t-1} =$ lagged value of the real price; and $t =$ time in months.

3.2. The Dynamic Model

There are many alternative models of dynamic analysis, which could be applied in market integration studies. But Mendoza and Rosegrant (1995) have proposed a multiple autoregressive commodity model and simplified it to a bivariate autoregressive (BAR) model to represent spatial pricing behavior. This model is recently used in many empirical studies to represent spatial market integration and pricing conduct with slight modifications. For instance Goletti (1994), Goletti and Christina-Tsigas (1995), Mendoza and Rosegrant, (1995a, 1995b), Minot and Goletti, (2000), and Kherallah *et al*. (2000) have used this model to estimate dynamic multipliers. The measure of spatial market integration by dynamic adjustments avoids the limitations of correlation coefficients, Timmer's index, and cointegration coefficients.

The dynamic model employed in the study was the BAR model. The short-run and the long-run estimates are known as dynamic multipliers, interpreted as the effect of a price change due to a random shock or a shift in an exogenous variable. This dynamic analysis was expected to provide more information than the cointegration procedure. Cointegration analysis is an econometric technique that allows the identification of presence of some sort of long-run relationship between markets and its direction, whereas the BAR analysis identifies and quantifies the magnitude and speed of market integration, and detects the direction of causal relationships between prices of markets (Goletti and Christina-Tsigas, 1995).

In the BAR model, the contemporaneous percentage price change in market i is a function of its own historical percentage price changes, and the contemporaneous and historical percentage price changes in market j specified follows;

$$\Delta P_{i,t} = \sum_{K=1}^{K=m_i} \alpha_{i,K} \Delta P_{i,t-k} + \sum_{h=0}^{h=n_i} \beta_{i,h} \Delta P_{j,t-h} + X_{i,t} \gamma_i + \varepsilon_{i,t} \qquad (2)$$

Where $\Delta P_{i,t}$ = Percentage change in monthly real retail price of wheat in market i at time t (months); *i.e.* contemporaneous percentage real price change; $\Delta P_{j,t-h}$ = Percentage change in monthly real retail price of wheat in market j at time $t-h$; *i.e.* lagged percentage real price change; $X_{i,t}$ = Exogenous variable such as seasonal dummies and time trend at time t, (*i.e.* instrumental variable); m_i and n_i = Number of lags in monthly percentage real retail price changes as identified by AIC procedure in market i and j respectively; $t-k$ = Historical percentage real price changes in market i; $t-h$ = Historical percentage real price changes in market j; $\alpha_{i,k}$ = Own lagged price effect; $\beta_{i,h}$ = Contemporaneous price multiplier (if $h=0$), and lagged price multiplier (if $h=1,2,...,n_i$) of market j on market i; $\gamma_{i,t}$ = Coefficient of instrumental variable; i and j = Spatially separated markets, and $i \neq j$; and $\varepsilon_{i,t}$ = Disturbance terms in market i at time t.

3.3. Tests and Specification Procedures

Before estimation of the dynamic measures of integration, the price series and the market pairs were tested for stationarity, cointegration, and causality; and the lag structure was specified.

3.3.1. Tests for Stationarity and Cointegration

To distinguish the presence of a unit root in the percentage price changes of wheat, the Augmented Dickey-Fuller (ADF) test was employed by estimating the following equation (with and without drift) and testing for the corresponding null hypothesis (Dickey and Fuller, 1979):

$$\Delta P_{i,t} = b_0 + \delta \Delta P_{i,t-1} + \sum b_i \Delta P_{i,t-k} + u_t \quad (3)$$

$$H_0 : \text{Percentage price change in market i has a unit root.}$$

Where u_t is the random term and $b_0, \delta, \text{and} b_i$ are coefficients to be estimated and tested.

The stationarity of the residuals from the individual time series is not sufficient to avoid spurious regressions. The

To check whether or not two markets were linearly cointegrated in the long run, the Engle-Granger (EG) two-step procedure was employed (Engle and Granger, 1987). If the linear combination of all the variables in (2) is tested for cointegration, the regression will not be spurious and this indicates that the linear autoregressive model represents the long-run price interdependence between markets. Accordingly, the BAR model indicated in equation (2) was estimated and the residuals from the estimation saved and tested for the presence of cointegration.

3.3.2 Lag Identification

Based on the monthly percentage price changes, the lag structure was identified using Akaike Information Criterion (AIC). The AIC procedure is one of the information based criterion most commonly used in econometrics, which suggests the choice of minimum number of explanatory variables to minimize the objective function that trades off parsimony against reduction in sum of squares (Akaike, 1969). In this case the AIC procedure was used to identify the lag length in months, and the number of lagged terms to be included in the model. The lag structure was identified by estimating equation (2) at chosen number of lags and then by selecting the lag length and number of lagged terms by AIC statistics. This selection was conducted by the residuals obtained and the parameters estimated in (2). For simplicity, the explanatory variables in the model were assumed to have linear combination and finally validated by AIC statistics, adjusted R^2 and F value.

The lag identification procedure avoids the problem of the use of uniform lag length. The lag length of the two variables in (2), one for percentage price changes in markets i and one for percentage price change in market j, was simultaneously estimated by the following objective function;

$$\mathrm{AIC}_{\mathrm{ij}} = \ln \hat{\delta}^{2}_{\mathrm{ij}} + \frac{2\,\mathrm{q}}{\mathrm{N}}\,; \qquad (4)$$

Where AIC_{ij} = the AIC statistic between prices of markets i and j; $\hat{\delta}^{2}_{ij}$ = estimated sample variance of the regression in equation (2); N = sample size of the time period; and q = number of explanatory variables in the model including the intercept.

Since both prices in market i and j respond to the same type of shock occurred in other markets, the problem of simultaneity is expected and that the error terms will be correlated with prices in market j. To overcome the problem of simultaneity, an instrumental variables estimation of $\Delta P_{j,t}$ was used, taking lagged values of the prices of all markets included in the study (Goletti and Christina-Tsigas, 1995). The two lags were determined simultaneously; but, zero lags of the instrumental variables were uniformly used.

3.3.3. Causality Tests

Granger causality test was used to establish the existence of a central market (Granger, 1969). Unlike the expected commodity flows, the test for information flow was conducted in both directions for all selected market pairs. This is important because more than one mode of price formations could coexist in a marketing system. Prices could be formed by both the reference and the local markets, because local markets could form prices based on the price formed in the reference market. Local markets could fix prices in collusion or cooperative way (Palaskas and Harris-White, 1993). This real situation calls for the need to analyze the impact of price shocks in both directions.

To conduct the test for causality, the market pairs of market i and j in (2) were considered. The effect of contemporaneous and lagged price changes in market j on contemporaneous price changes in market i were analyzed separately by estimating the restricted regression and the residuals were compared with the results of the unrestricted regression in (2). The test was conducted based on the residuals of the following restricted regression and the corresponding hypothesis;

$$\Delta P_{i,t} = \sum_{h=o}^{h=n_i} \beta_{i,h} \Delta P_{j,t-h} + X_{i,t-h} + e_{i,t}\ ; \qquad \textbf{(5)}$$

$H_o : \beta_{i,h} = 0;\ h = 0,1,2,...,\ n_i$; Independent.

The residual sum of squares obtained from the two regressions was used to test the existence of causal relationship between market pairs. Based on this idea, markets were tested for their unidirectional, bilateral (interdependent), or independent (segmented) relationships by the following F-statistic;

$$F = \frac{(R_{ur}^2 - R_r^2)/m}{(1 - R_{ur}^2)/(N - k)} \qquad \textbf{(6)}$$

Where $R^2_{ur} =$ unadjusted coefficient of determination for unrestricted regression; $R^2_r =$ unadjusted coefficient of determination for restricted regression; $k =$ number of parameters estimated in the unrestricted regression; $m =$ number of linear restrictions (explanatory variables omitted in the restricted regression); and $N =$ sample size in the unrestricted regression.

The causality test was used to identify the direction of causal relationship between pairs of 10 markets. This requires considering 10 bivariate autoregressive equations (20 market pairs), but estimation for price flows was conducted in both directions of the market pairs, each with residuals to be estimated and tested for the 20 equations. This test enables to select market pairs with significant causal relationships and identification of the major markets.

3.4. Estimation

The dynamic measure of integration including dynamic multipliers, speed of price adjustment, and composite index were estimated to measure the magnitude, speed, and extent of integration.

3.4.1. Dynamic Multipliers

Equation (2) is a reduced form representation of price changes as a function of historical price changes in one market and those in the other markets. Estimation is, therefore, possible as the problem of simultaneity is eliminated (Kherallah *et al.,* 2000, Mendoza and Rosegrant, 1995a, 1995b; Goletti and Christina-Tsigas, 1995). The first task in the estimation stage was to estimate the mean value of the regression (2) based on the identified lag structure. This estimation of the mean value enables to detect the average impact of contemporaneous and lagged price changes.

The dynamic multipliers represent quantified percentage of price transmission. They could be short-run; interim; or long run. Short-run dynamic multipliers give the change in the mean value of the dependent variable following a unit change in the explanatory variable in the same time period. If the change in the explanatory

variable is maintained at the same level thereafter, then, the sum of the partial coefficients gives the change in the mean value of the dependent variable in the next period. The sum of the coefficients in the second period gives the change after the second period, and so on. These partial sums are the interim dynamic multipliers, and the computation procedure continues up to k periods, until the intermediate multipliers converge to a steady state. The long-run dynamic multiplier is reached at the regression including the k^{th} lag. It is the sum of the impact multipliers of the regression at the maximum lagged variable estimation.

Market pairs with contemporaneous responses have instantaneous responses and hence long-run dynamic multipliers are not computed. Long-run dynamic multipliers are computed for market pairs with lagged responses. The dynamics of the adjustment process involves a series of interim multipliers. If nonzero lags are estimated, the price shock in a market will take time to affect the price change in the other market. It also takes time to complete the price adjustment process caused by the shock. Hence, based on equation (2), the immediate impacts, or the short-run multipliers, are given by the coefficients, $\beta_{i,0}$ (since h = 0). The cumulative effect of an exogenous shock to changes in the retail prices of wheat in market j on the changes in retail prices of wheat in market i after k periods was calculated as

$$\lambda_{ij}^{k} = \sum_{h=0}^{k} \frac{\partial E(\Delta(_{i,(t)})}{\partial \Delta P_{j,(t-h)}} \qquad \textbf{(7)}$$

Where λ_{ij}^{k} = Average dynamic interim multiplier after k periods; E = expectation operator based on the price data at time t; k = periods of adjustment in months; h = lag length $(h = 0,1,2,...k)$; and ∂ is partial derivative operator.

The dynamic multipliers in equation (8) were computed after each lag period to get the cumulative effect at the end of that period. As mentioned above, the adjustment process takes time, and the full adjustment of the dynamic process in equation (7) is given by the limit of the sequence as follows;

$$\lambda_{ij} = \lim_{k \to \infty} \lambda_{ij}^{k} \qquad \textbf{(8)}$$

Where λ_{ij} =Long-run dynamic multiplier after k periods; and ∞ =infinity.

The order of the autoregressive process in the EG test is expected to estimate the length of time it takes for markets to attain full adjustment. It is estimated by the AIC procedure though the speed of adjustment between markets identified by the AIC is parsimonious. This method is also applied, with slight modifications, in empirical studies by, for instance, Goletti (1994), Goletti and Christina-Tsigas (1995), Minot and Goletti (2000), and Kherallah *et al*. (2000). Hence, the speed of spatial price adjustment indicates the extent of market integration between markets in sense that markets with speedy price adjustment are more integrated, and those with sluggish price adjustment are less integrated.

3.4.2 Composite Index

The speed of price adjustment estimates the length of time required to react to price changes occurred in other markets. The combination of magnitude and speed of price adjustment generates another actual measure of market integration, denoted by:

$$\mu_{ij} = \frac{\lambda_{ij}}{k_{ij}} \qquad \textbf{(9)}$$

Where μ_{ij} =Composite measure ($0 \leq \mu_{ij} \leq 1$);

k_{ij} =Speed of adjustment in months between market i and j.

This measure has two advantages over the other measures of market integration. First, it combines the information of two measures into one, and second it can rank the market integration across different markets in a country or across countries. The Value of μ_{ij} closer to one indicates more integration of markets and the value closer to zero indicates less integration of markets (Goletti and Christina-Tsigas, 1995). A market with more magnitude and shorter reaction time has higher spatial integration and integration of all selected markets was ranked using this index.

3.5. Pricing Conduct

Markets could be highly integrated in inefficient markets or could be segmented by deliberate action of marketing agents. This is because, short-run integration may be generated by collusive pricing (Mendoza and Rosegrant, 1995a, 1995b). According to the structure-conduct-performance approach of market analysis, efficiency is determined by structure, conduct, and performance of a market. Market conduct refers to the pattern of commercial behavior arising from market structure. Market conduct includes pricing conduct (predatory, exclusionary, collusive, or competitive), product strategy, responsiveness to change, research and innovation, and advertising. Markets may be perfectly competitive; monopolistic; or oligopolistic (Mendoza and Rosegrant, 1995; Pomeroy and Trinidad, 1995; Tilburg and Lutz, 1995). Commodity markets in developing countries are assumed to be oligopolistic.

Oligopoly is said to exist when more than one seller is in the market but when the number is not large to make the contribution of each negligible. A typical oligopoly exists when for example, three firms control over 50% of all sales of a particular good in a particular market and certain barriers prevent potential competitors from entering the market (Pomeroy and Trinidad, 1995). Oligopolistic markets are characterized by 3 pricing behavior: price discrimination, organized pricing, or price matching with offsetting lags.

Economic theory states that prices in competitive markets are determined by supply and demand conditions. If spatially separated markets with low marketing infrastructure fix prices competitively, supply and demand conditions cannot be adjusted instantaneously. But if markets set prices noncompetitively, spatial markets, even those with low marketing infrastructure, will be highly integrated instantaneously by organized action of marketing agents.

Ethiopian wheat markets are suspected for noncompetitive price setting behavior. On a given day, brokers determine up to 11 prices for wheat (and 40 prices for principal grains) traded in Addis Ababa. “The grain market structure does not have a role for market makers who openly purchase unmatched orders at a discount and sell unmatched orders at a premium in order to pay the price of immediacy There is an implicit rule governing the brokers” (Eleni, 2001). A high degree of price

integration among markets does not necessarily imply that the market system is functioning properly (Tilburg and Lutz, 1995). Hence, spatial market integration analysis should be complemented with analysis of pricing behavior to conclude about spatial efficiency. If a marketing system is allocatively efficient, consumer preferences are transferred without distortion to producers who will use the price information to make production decisions which are allocatively efficient (Harris-White, 1995).

In this study, the pricing behavior of traders was assessed to detect whether it is characterized by conducts like spatial price discrimination, collusion, price leadership, or competition. The average partial impacts estimated from equation (2) were used to test the pricing conduct of all the selected markets. The dynamic model in equation (2) captures the dynamic price relationship and provides a direct and explicit testing of pricing conduct. A market could be affected by both contemporaneous and historical price changes in other markets. These effects were separately treated and analyzed to identify the pricing conduct in each market. Accordingly, the assumed imperfect wheat markets in Ethiopia were tested for the following 3 hypotheses of oligopolistic pricing conduct;

Hypothesis I: Spatial price discrimination, or market independence;

$$H_o^1 : \beta_{i,h} = 0; h = 0,1,2,..., n_i . \quad \textbf{(10)}$$

Hypotheses II: Collusive pricing or perfect cooperative pricing;

$$H_o^2 : \beta_{i,0} = 1; \text{and } \alpha_{i,k} = \beta_{i,h} = 0; k = 1,2,... m_i \quad \textbf{(11)}$$

Hypotheses III: Price matching with delayed responses and offsetting lags;

$$H_o^3 : \beta_{i,0} = 1, \text{ and } \sum_{k=1}^{k=m_i} \alpha_{i,k} + \sum_{h=1}^{h=n_i} \beta_{i,h} = 0. \quad \textbf{(12)}$$

The first hypothesis refers to the situation when price changes in market j do not affect price changes in market i. Hypothesis II indicates an organized collusive pricing system of instantaneous price arrangements between marketing agents in two spatial markets. The last hypothesis postulates an unorganized market in a base

point pricing system based on reference markets that indicates a price leadership system. If all the three hypotheses are false, a non-cooperative form of pricing arrangement is said to exist and the pricing system could be considered as competitive (Mendoza and Rosegrant, 1995a), and markets are actually integrated in an efficient pricing system. These tests validate the existence of real long run price relationships among markets and identifies whether the pricing behavior is competitive or noncompetitive.

3.6. Determinants of Spatial Integration

The effect that structural factors have on market integration explains why markets are integrated. Market integration analysis without the identification of the determinants of integration does not indicate the appropriate intervention measures to be taken for improvement. Developed structural factors that determine market integration are expected to be associated with well-integrated markets while weak market integration is the result of structural deficiencies. Analysis of market integration measures alone is not sufficient to recommend on requirements of market improvement strategies.

The comparison of various measures as well as analysis of the structural factors affecting these measures of market integration is necessary in two sets of issues. First, it gives the concept and measurement of market integration to interpret, to measure, to translate into operational concept, and to identify the relation of each measure and the insights to be derived. Second, the type and extent of the relationship between market integration and structural factors can be identified and estimated (Goletti, 1994).

The strength of market integration and the speed of spatial price adjustment are expected to be determined by the structural factors of market integration including road distance, marketing infrastructure, dissimilarity in production (market volumes), industry concentration ratio, market types (urban and rural), price stabilization policy, and other supply shocks (Goodwin and Schroeder, 1991; Palaskas and Harris-White, 1994; Goletti and Christina-Tsigas, 1995; Kherallah *et al*, 2000). In the Ethiopian context, the expected effects of selected factors on the measures of market integration were hypothesized as summarized in Table 1.

Table 1: Structural factors of spatial market integration and their expected effects

Explanatory variable	Unit of measurement	Expected coefficient
Inter-market road distance	Road distance between two markets (kilometers).	Negative
Road density	Total distance of all weather roads in the surrounding area of two markets (kilometers) per total surrounding area of the two markets (thousand square kilometers)	Positive
Dissimilarity in per capita production (DPCP)	Absolute value of the difference in wheat production per capita per year(kilograms per capita per year)	Positive
Dissimilarity in population density (DPD)	Absolute value of the difference in population density (inhabitants per square kilometer).	Positive
Production shocks*	Number of wheat production shocks in the surrounding area of the two markets.	Negative

*: There was no wheat production shocks observed in the study period.

Based on the above a priori relationships of the structural factors with market integration measures, the most determinant structural factors were identified. The models for all market integration measures were specified using the AIC procedure first by assuming two alternative models with higher coefficient of determination, linear and linear-logarithmic (Lin-Log), each with 3 and 4 structural variables, and then selecting the one which fits best. The functional relationship was identified to be the Lin-Log model for all measures of market integration defined as follows;

$$M_{ij} = \beta_1 \ln D_{ij} + \beta_2 \ln RD_{ij} + \beta_3 \ln DPCP_{ij} + \beta_4 \ln DPD_{ij} + e_{ij} \qquad \textbf{(13)}$$

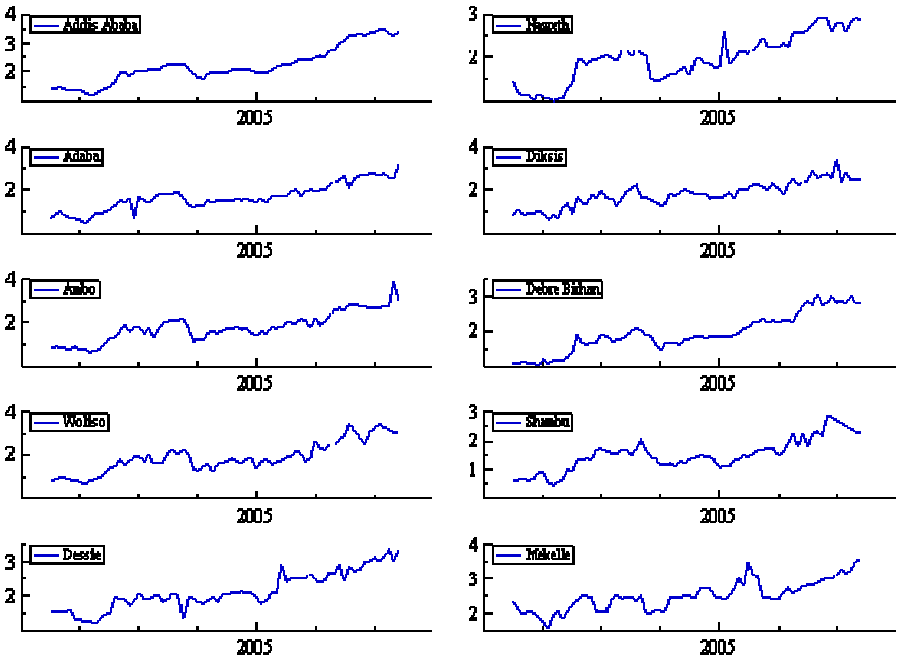
Where M_{ij} =estimated measure of market integration between market i and j; D_{ij} = inter market road distance; RD_{ij} =road density of the area surrounding the two markets; $DPCP_{ij}$ =dissimilarity in wheat production per capita between the two markets; DPD_{ij} =dissimilarity in population density between the markets; ln= natural logarithm, and e_{ij} =disturbance term.

4. Results and Discussion

4.1. Unit Root and Cointegration Tests

Food prices have been drastically developing in Ethiopia's domestic markets since the late 1990s. Price in all markets considered were in general moving together indicating that use of nominal price would lead to spurious regressions because of the nonstationary nature of prices. To detect how spatial prices in supply and destination markets were moving was easily detected by plotting the nominal price series in the 10 markets selected (Figure 1). This pattern has some implications on how wheat prices in different markets were moving together over time and the degree to which prices and spatial margins were instable.

Figure 1: Patterns of wheat prices in Ethiopian major markets (July, 2001-June, 2007)



Source: Plotted from data in CSA, Monthly Statistical Bulletins, various issues.

As the focus of this paper is pattern of price co-movement between spatial markets rather than univariate price analysis, wheat prices were transformed to percentage price changes and these transformed variables were tested for the presence of unit

roots. Accordingly, the null hypothesis that the time series of the percentage price changes in a market has a unit root was rejected for all markets at 1% level of the ADF test statistic (Table 2). The monthly percentage price series for each wheat market was individually integrated. This econometric integration of each series was attained by the relevant price transformation which eliminated trends and other variables moving with time.

Table 2: Unit root test results for percentage price changes of wheat in Ethiopian markets (July, 2001-June, 2007).

Percentage price change	Lag length	With drift		Without drift	
		ADF statistics	Critical values (1%)	ADF statistics	Critical values (1%)
Addis Ababa	0	-8.712**	-3.527	-8.768**	-2.598
Nazreth	1	-7.909**	-3.527	-7.964**	-2.598
Adaba	2	-6.315**	-3.530	-6.312**	-2.599
Diksis	1	-8.813**	-3.527	-8.868**	-2.598
Ambo	0	-11.453**	-3.527	-11.481**	-2.598
Debre Birhan	7	-2.761*	-3.538	-2.784**	-2.602
Woliso	1	-8.149**	-3.527	-8.169**	-2.598
Shambu	4	-6.350**	-3.528	-6.262**	-2.598
Dessie	1	-9.505**	-3.527	-9.434**	-2.598
Mekelle	0	-9.124**	-3.527	-9.163**	-2.598

Note: Lag order selection in the unit root testing procedure was routinely informed by Akaike information criterion (AIC) to eliminate the difference in test results expected to be significant if we use different lag specification procedures like Schwarz information criterion (SIC). This is because different procedures have different levels of punishment for new lags to be included into the model. Accordingly, the authors have reported tests only from the AIC procedure to secure uniformity and comparison among all other tests. It is also verified that there is some difference in test results in using a model with or without drift for Debre Birhan percentage price changes. **: Significant at 1% level. *: Significant at 5% level.
Source: Computed from data in CSA, Monthly Statistical Bulletins, various issues.

The econometric integration of individual time series may not lead to the linear cointegration of percentage price changes in the BAR model considered in equation (2). The test for the nonstationarity of the residuals from the bivariate linear combination of these stationary series has resulted in stationary residuals, except

for two market pairs, indicating that their linear combination in a bivariate model is cointegrated. The hypothesis that the percentage price changes are cointegrated was rejected for two market pairs, Addis Ababa causes Diksis and Addis Ababa causes Shambu. These two market pairs were not cointegrated in their linear BAR representation for which long run multipliers were not computed.

4.2. Causal Relationships

The analysis of the causal impact of price shocks in each origin market on the destination market, and vice versa is presented in Table 3. The causality of price changes at Addis Ababa on the price changes in Woliso, Debre Birhan, and Diksis markets is significant at 5% level. Addis Ababa has very strong causal effect onto Ambo and Adaba markets. The causal effect of price changes in Addis Ababa was weak and/or insignificant on other markets, but the reverse causality effect was stronger for most market pairs. Moreover, for most market pairs, this weaker causal effect of Addis Ababa market on other markets was not explained by the linear BAR model as indicated by the adjusted coefficient of determination.

On the other hand, Nazreth wheat market influences the formation of prices in Diksis strongly (1% level) while it has weak and very weak effect on Adaba and Addis Ababa, respectively. Only the Adaba market has a very weak casual effect on Nazreth. The causal relationship indicates that the effect of price changes in Nazreth on the price changes in the other markets is stronger than the effect of the Addis Ababa market on other markets, implying that Nazreth wheat market is more central as compared to the Addis Ababa wheat market. The causal relationship estimated between Addis Ababa and Nazreth was verified to be similar with the results of Kindie *et al* (2006), even though the two models and the estimation procedures are different.

Table 3: Tests of Granger causality and validation of the bivariate model for wheat prices in Ethiopia (July 2001-June 2007).

Spatial market pairs	Lag length	Causality $F = \frac{(R^2_{ur} - R^2_r)/m}{(1 - R^2_{ur})/(N - k)}$	Model validation (equation 2)	
			Adjusted R^2	F-value
Addis Ababa →Nazreth	0	0.472	-0.023	0.204
Addis Ababa →Ambo	2	6.044**	0.407	8.877**
Addis Ababa →Debre Birhan	0	4.017*	-0.006	0.799
Addis Ababa →Diksis	0	6.048*	-0.020	0.310
Addis Ababa →Adaba	1	33.508**	0.373	11.428**
Addis Ababa →Woliso (A)	1	2.147	0.397	6.834**
Woliso →Addis Ababa	3	8.158**	0.250	6.589**
Shambu →Addis Ababa	0	0.904	0.352	1.193
Nazreth →Addis Ababa (A)	3	1.811	0.713	22.078**
Ambo →Addis Ababa	4	14.41**	0.568	9.827**
Debre Birhan →Addis Ababa	4	18.432**	0.784	25.338**
Diksis →Addis Ababa	4	4.807**	0.805	28.687**
Adaba →Addis Ababa	0	0.767	0.236	11.795**
Woliso →Addis Ababa	3	8.158**	0.250	6.589**
Nazreth →Diksis	2	29.039**	0.649	22.286**
Diksis →Nazreth	1	2.596*[a]	0.488	17.657**
Nazreth →Adaba (B)	0	2.796	0.173	14.470**
Adaba →Nazreth (B)	0	3.458	0.394	0.362
Dessie →Mekelle	2	31.116**	0.731	32.233**
Mekelle →Dessie	1	87.432**	0.713	44.389**

Note: The results indicate that Nazareth is not granger caused by Addis Ababa wheat market. *: Causality is significant at 5% level. **: Causality is significant at 1% level. A: Very Weak causality (significant at 25% level). B: Weak causality (significant at 10% level).

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

4.3. Interim Multipliers

Based on the results obtained from estimating equation (2), Addis Ababa wheat market has a significant contemporaneous (short run) price effect only on Ambo market (1.05%). Except the Debre Birhan wheat market, all the other markets have significant contemporaneous price effects on Addis Ababa. The lag impact of the Addis Ababa market on Adaba wheat market was, however, higher. As indicated by the results of causal effects in the previous section, for most market pairs, the estimated price effects of Addis Ababa market on Nazreth and other surplus markets was weak or insignificant (Table 4).

Table 4: Contemporaneous and lagged price effects on the responses across wheat markets (July 2001-June 2007).

Spatial market pairs	Lag length (month)	Contemporaneous price effect $\beta_{i,0}$	Lagged price effects $\sum_{h=l}^{h=n_i}\beta_{i,h}$
Addis Ababa →Nazreth	0	0.155	_
Addis Ababa →Ambo	2	1.053*	-0.070
Addis Ababa →Debre Birhan	0	-0.276	_
Addis Ababa →Diksis	0	0.152	_
Addis Ababa →Adaba	1	-1.358	0.881
Addis Ababa →Woliso	1	0.701	-0.613
Nazreth →Addis Ababa	3	0.377**	0.710
Ambo →Addis Ababa	4	0.105**	0.340
Debre Birhan →Addis Ababa	4	0.090	1.347
Diksis →Addis Ababa	4	0.087**	0.383
Adaba →Addis Ababa	0	0.040**	_
Woliso →Addis Ababa	3	0.120**	0.231
Nazreth →Diksis	2	-0.139	-0.007
Nazreth →Adaba	0	0.398**	_
Diksis →Nazreth	1	0.410**	0.179
Adaba →Nazreth	0	0.012	_
Dessie →Mekelle	2	0.330**	1.017
Mekelle →Dessie	1	0.632**	-0.023

Note: *: Significant at 5%. **: Significant at 1% level

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

The significant contemporaneous price effects of Nazreth, Ambo, Diksis, Adaba and Woliso on Addis Ababa were 0.38, 0.11, 0.09, 0.04, and 0.12, respectively. The lag price effects of Nazreth, Ambo, Woliso, Debre Birhan, and Diksis were 0.71, 0.34, 0.23, 1.35 and 0.38, respectively. The higher lag effects on Addis Ababa were granger caused by Debre Birhan and Nazreth markets. There were no lag effects from Adaba market in the study period. The lag price effect of Nazreth, Ambo, Debre Birhan, and Diksis on Addis Ababa was higher indicating the dominance of these surplus markets in the process of price formation to affect the Addis Ababa wheat market. This justifies that wheat prices are first discovered at the surplus markets, and then transmitted to the destination markets. This is related to the fact that wheat prices are determined by the change in the supply of wheat, wheat supply shocks, in the surplus markets rather than the demand at the Addis Ababa wheat market. However, the price transmission from the majority of the surplus markets to the Addis Ababa market was very sluggish taking 3 to 4 months. Unlike other surplus markets, the price information transmission from Adaba market to Addis Ababa was completed within a month.

Nazreth has a significant contemporaneous effect on the other 2 markets trading with it (i.e. Addis Ababa and Adaba) and is affected only by Diksis with lower magnitude. Assuming that there is no spatial pricing conduct problem, the contemporaneous and lag effect of Nazreth on Addis Ababa indicates the central role of Nazreth in discovering wheat prices in Ethiopia. Nazreth was affecting prices in other markets including Addis Ababa very sluggishly and the reverse effect was almost insignificant.

The contemporaneous price effect of Mekelle on Dessie was higher (0.63) than the effect of Dessie on Mekelle (0.33). The lag effect of Dessie on Mekelle was 1.02. The Mekelle market contemporaneously affects prices in Dessie but, in the long-run, price effect of Dessie on Mekelle was very high indicating that Dessie was more influential than Mekelle.

The findings of this result generally indicate that prices formed in Nazreth are significantly transmitted to Addis Ababa and other surplus markets, but prices formed in Addis Ababa are not transmitted onto other markets (except Ambo). The same thing is true for the price transmission from other markets to Addis Ababa. The

effect of other markets onto Addis Ababa was stronger than the effect of the other markets on Nazreth. To test whether Addis Ababa or Nazreth is the dominant market for wheat price formation in the country, there are two alternative conditions. If there is no spatial pricing inefficiency in these reference markets, then Nazreth will be the central market, and the wheat marketing system is competitive. But, if there is significant spatial price discrimination, it will be irrelevant to identify a central market in the presence of market failure or bad market structure. This is verified in the next section by employing the tests that help in identifying the spatial pricing behavior of the marketing agents operating in these markets.

4.4. Long-run Multipliers

Table 5 indicates 12 market pairs with casual relationships (67%) for which significant long-run multipliers are computed. Significant negative long-run multipliers were computed for two market pairs, i.e. Addis Ababa causes Adaba and Nazreth causes Diksis. These negative long-run multipliers cannot be defined because they have no a priori meaning. Moreover, the price adjustment takes place instantaneously, within a month, for two market pairs (Adaba causes Addis Ababa and Nazreth causes Adaba), for which long-run multipliers were not computed.

The results indicate that the cumulative effect of wheat price transmission from Addis Ababa to other markets is very much limited affecting only two markets. A 1% price change in Addis Ababa results in 0.98%, and 0.09% price changes in Ambo and Woliso, respectively. But this amount of shock in other markets leads to a price change in Addis Ababa amounting to 1.1% from Nazreth, 0.45% from Ambo, 1.44% from Debre Birhan, 0.47% from Diksis, and 0.35% from Woliso. The maximum price transmission was estimated from Debre Birhan to Addis Ababa market.

The estimated long-run price transmission from Nazreth to Addis Ababa was about 1.1% and the length of time required for the price adjustment was 3 months which is much longer than the time expected for price transmission between the two nearby markets. Interestingly, the long-run multiplier from Diksis to Nazreth was 0.59% taking 1 month to complete the adjustment. However, the percentage of price transmission from Dessie to Mekelle was 1.35% which is higher but sluggish taking at least 2 months to complete the price adjustment in Mekelle. The long-run multiplier

for the price transmission from Mekelle to Dessie was 0.61%. The price transmission between Mekelle and Dessie, with a distance of 382 kilometers in between, is higher and speedier than the price transmission between Nazreth and Addis Ababa, with a distance of 100 kilometers in between.

Table 5: Estimates (A) of long-run price transmission between wheat markets (July 2001-June 2007).

Market pairs and direction of causality	Long-run multiplier $\lambda_{ij} = \lim_{k\to\infty} \lambda_{ij}^{k}$
Addis Ababa →Ambo	0.98**
Addis Ababa →Adaba (B)	-0.48**
Addis Ababa →Woliso	0.09**
Ambo →Addis Ababa	0.45**
Debre Birhan →Addis Ababa	1.44**
Diksis →Addis Ababa	0.47**
Woliso →Addis Ababa	0.35**
Nazreth →Addis Ababa	1.10**
Nazreth →Diksis (B)	-0.15**
Diksis →Nazreth	0.59**
Dessie →Mekelle	1.35**
Mekelle →Dessie	0.61**

Note: A: Only significant estimates are indicated. B: The computed long-run multipliers for the two market pairs were negative. These are considered as if there were no significant and meaningful long-run price effect between these markets. **: Significant at 1% level.
Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

The lower and sluggish price transmission between markets around the assumed reference markets could be because of the prevalent marketing system and level and distribution of factors determining spatial market integration. The results generally indicate that wheat markets in Ethiopia, except Ambo, are not very much affected by price shocks in Addis Ababa; rather price shocks in Nazreth and other supply markets highly affect prices in Addis Ababa slowly. However, the speed of price transmission from Addis Ababa to other markets is faster than the speed of price transmission from supply markets to Addis Ababa. This sluggish price

transmission from supply markets might be related to the flexibility and responsiveness of the destination and the supply markets in the wheat price formation process.

4.5. Composite Index

A measure of spatial market integration combining both the magnitude and the speed of price transmission is considered as the composite index. The composite index computed for significant positive long-run multipliers is summarized in Table 6. It shows the percentage of price transmission per month. The three most integrated wheat market pairs in Ethiopia showed a composite index of 0.67% (Dessie causes Mekelle), 0.61% (Mekelle causes Dessie), and 0.59 (Diksis causes Nazreth). This means that a 1% price change in Dessie, Mekelle, and Diksis leads to 0.67%, 0.61%, and 0.59% price change per month in Mekelle, Dessie, and Nazreth, respectively. The 3 most weakly integrated market pairs were Woliso causes Addis Ababa (0.12%), Ambo causes Addis Ababa (0.11%), and Addis Ababa causes Woliso (0.09%).

Table 6: Extent of price adjustment across the major wheat markets in Ethiopia (July 2001-June 2007).

Spatial market pairs and direction of causality	Composite index $\mu_{ij} = \frac{\lambda_{ij}}{k_{ij}}$
Addis Ababa →Ambo	0.492
Addis Ababa →Woliso	0.087
Nazreth →Addis Ababa	0.365
Debre Birhan →Addis Ababa	0.359
Diksis →Addis Ababa	0.118
Woliso →Addis Ababa	0.117
Ambo →Addis Ababa	0.113
Diksis →Nazreth	0.589
Dessie →Mekelle	0.674
Mekelle →Dessie	0.609

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

4.6. Pricing Behavior

The price discovery by an organized action of traders could make spatial markets highly integrated while they are not actually integrated in the long-run. A high degree of price integration among markets does not necessarily imply that the marketing system is functioning properly (Tilburg and Lutz, 1995). The three hypothesized pricing conduct of oligopolistic markets were tested in the selected wheat markets (Table 7). All the market pairs with significant short-run or long-run multipliers were tested for the 3 hypothesized pricing conduct models.

The first hypothesis, which tests the presence of spatial price discrimination, was accepted in some market pairs trading with Addis Ababa and Nazreth. Addis Ababa plays a discriminatory role on supply markets without alternative market outlets, and supply markets with attentive outlets discriminate these destination markets. This indicates that supply markets exercise discriminatory role on the destination markets if prices are not better than prices in alternative market outlets including Mekelle and Kenya. The absence of long-run price transmission form Addis Ababa to Nazreth might be related to the pricing conduct of traders in Addis Ababa. The remaining two hypotheses, *i.e.* perfect cooperative pricing and price matching with offsetting lags, were rejected for all the market pairs. The exercise to cooperatively fix and match prices between two markets was not accepted for all market pairs. However, no market pair was identified for its competitive pricing system because not all hypotheses were rejected for all market pairs. This is explicit evidence about the presence of noncompetitive pricing behavior in the wheat markets.

Table 7: Tests of spatial pricing conduct in the major Ethiopian wheat markets (July 2001-June 2007).

Spatial market pairs and direction of causality	t tests for unity contemporaneous price effect $H_0 : \beta_{i,0} = 1;$ $H_1 : \beta_{i,0} < 1$	Hypothesized spatial pricing behavior (F tests)		
		Hypothesis I: Spatial price discrimination	Hypothesis II: Instantaneous and perfectly cooperative pricing	Hypothesis III: Perfect price matching with offsetting lags
Addis Ababa →Nazreth	-25.431**	0.351	0.401	0.401
Addis Ababa →Ambo	0.891	8.906**	9.234**	7.819**
Addis Ababa →Debre Birhan	-48.7479**	0.540	1.642	0.077
Addis Ababa →Diksis	-13.670**	0.817	2.671	1.238
Addis Ababa →Adaba	-23.237**	2.739*	14.059**	0.930
Addis Ababa →Woliso	-5.212**	8.244**	8.259**	11.987**
Nazreth →Addis Ababa	-104.845**	32.888**	8.666**	12.026**
Ambo →Addis Ababa	-293.036**	3.613**	6.855**	3.359**
Debre Birhan →Addis Ababa	-80.964**	13.924**	28.073**	16.799**
Diksis →Addis Ababa	-266.901**	35.616**	26.743**	32.623**
Adaba →Addis Ababa	-803.194**	9.767**	10.001**	14.859**
Woliso →Addis Ababa	-250.230**	4.232**	4.055**	3.924**
Shambu →Addis Ababa	-258.015**	0.891	0.505	0.188
Nazreth →Adaba	-65.412**	10.090**	7.581**	10.096**
Nazreth →Diksis	-73.916*	10.179*	26.433*	9.114*
Diksis →Nazreth	-96.790**	22.172**	1.219	1.814
Adaba →Nazreth	-551.080**	1.329	0.949	0.055
Dessie →Mekelle	-84.325**	16.955**	24.648**	19.510**
Mekelle →Dessie	-20.664**	13.105**	42.477**	19.183**

Note: *: Significant at 5% level. **: Significant at 1% level.

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

Market pairs with spatial price discrimination as tested in Table 7 were identified and separately presented in Table 8. The nature of spatial price discrimination or market independence between destination (Addis Ababa and Nazreth) and supply markets can be verified by examining the reverse price transmission, the availability of alternative market outlets for supply markets, and the price levels and pricing conduct prevalent in the destination markets.

The price changes in Nazreth, Debre Birhan, and Diksis were transmitted to Addis Ababa, but there was no price transmission from Addis Ababa to these markets. The significant price transmissions estimated from Addis Ababa were negative to Adaba (-0.48%), and very small to Woliso (0.09%). The magnitude of price transmission from Ambo was the only meaningful and indicative measure estimated. As explained in the previous sections, the effect of price transmission from other markets to Addis Ababa was high and significant but the reverse effect on other markets was discriminatory. Out of the 5 markets which have high and significant price effects on Addis Ababa, Ambo was the only wheat market that was highly and significantly affected by the Addis Ababa market. The discriminatory role of the destination markets was offset by using alternative market outlet in Adaba, Debre Birhan, and Shambu. The price discrimination by Adaba on Nazreth, Addis Ababa on Debre Birhan, and Shambu on Addis Ababa is expected to be the result of alternative trade route change to Adaba-Awassa-Kenya, Debre Birhan-Dessie-Mekelle, and Shambu-Bahir Dar-Mekelle, respectively. The supply markets without alternative market outlets like Ambo and Woliso were not significantly discriminated.

Table 8: Wheat markets with spatial price discrimination (July 2001-June 2007).

Spatial market pairs and direction of causality	Long-run price transmission	F tests for price discrimination
Addis Ababa →Nazreth	Discriminated	Accepted
Addis Ababa →Debre Birhan	Discriminated	Accepted
Addis Ababa →Adaba	Negative	Rejected
Addis Ababa →Woliso	Very small	Rejected
Adaba →Nazreth	Discriminated	Accepted
Shambu→Addis Ababa	Discriminated	Accepted

Note: **: Significant at 1% level.

Source: Computed from data in CSA Monthly Statistical Bulletins, various issues.

This is a strong evidence to justify that wheat marketing middlemen in Addis Ababa fix prices discriminatively. They exercise spatial price discrimination on traders operating in other markets of Ethiopia. This means that retail price changes formed in Addis Ababa were protected from transmission onto other markets by the action of marketing middlemen in this destination market. The price discrimination could be used to secure high spatial margins which might be shared among suppliers in supply markets

and buyers in Addis Ababa by protecting the price shock in Addis Ababa from transmission. This mechanism could avoid transmission of price shocks to supply markets so that prices will not rise in the supply markets and the maximum spatial margins would be secured in destination markets. These marketing middlemen, as verified by Eleni (2001), might include the powerful brokers in Addis Ababa.

However, it is also empirically justified by the results that traders in Nazreth did not (or did not able to) fix prices discriminatively on other markets. That is why price changes in Nazreth were highly reflected in Addis Ababa. Supply market like Adaba and Shambu change their market outlets and try to establish short-run market independence. Generally, the test for spatial price discrimination justifies the presence of problem of pricing behavior in destination markets and the actions taken by supply markets to overcome the problem. The wheat marketing system in Ethiopia was verified to suffer from inefficient pricing system.

4.7. Determinants of Spatial Integration

In this section, the three market integration measures, *i.e.* long-run multipliers, speed of price adjustment, and composite index were used for analyzing the effect of structural factors on market integration. Five structural factors of wheat market integration were hypothesized to determine the level of integration of wheat markets in Ethiopia. These factors were inter-market road distance, road density surrounding the two markets, DPCP, and DPD between the two markets and the number of production shocks. The relevance and the functional form of the variables were specified by AIC procedure. According to production data in CSA for 2001/02-2006/07 production years, there was no significant wheat production shock in the area surrounding the selected markets and the number of production shocks as a variable was not included in the analysis. Moreover, out of the remaining four variables, DPD was not relevant variable for all the market integration measures. The estimation indicates that, except DPD, the other three variables were relevant to determine the level of wheat market integration in Ethiopia (Table 9).

Table 9: Validation and summary results of the structural determinants of wheat market integration (July 2001-June 2007).

Factors of spatial integration and validation techniques	Coefficients (equation 13)		
	Speed of adjustment (months)	Long-run multiplier	Composite index
Road distance	-0.686**	-0.314*	-0.087
Road density	1.408**	0.817**	0.358*
DPCP	-0.092	-0.352**	-0.228**
Adjusted R^2	0.883	0.840	0.695
d statistic	1.713	2.170	2.061
F-value	33.642	20.202	9.365

Note: .Only significant estimates are presented. *: Significant at 5% level. **: Significant at 1% level.

Source: Computed from data in CSA and Annual Reports of Regional Roads Authorities (Amhara, Oromia, Tigray, and Addis Ababa), various issues.

The model fitness, as validated by the adjusted coefficient of determination, is high (at least 70%) for all the integration measures estimated. The fitness was 88.3% for the speed of adjustment, 84.0% for the long run multiplier, and 69.5% for the composite index. The case wise diagnostics indicate that the residuals from the regression were stationary as validated by the computed d-statistics implying that the models are properly specified and the relevant variables included. It is found that the fitness of the models relatively decreases as the accuracy of the integration measures increase. Generally, the result indicates that the selected factors were relevant and sufficiently explain the amount and the sources of the variation in market integration. However, about 12% to 30% of the variation in market integration measures was not explained by the assumed structural factors requiring further studies to identify other structural, institutional, and policy factors of integration.

Distance is expected to influence market integration negatively. Its effect on the market integration was negative as expected for all measures of integration. As the distance between the spatial markets decreases, the integration of the markets increases. Road density of the area surrounding the markets was positively related with all market integration measures as expected. It significantly and positively

affects wheat market integration. It was generally observed that the magnitude of the parameter estimates decreases as the accuracy (or robustness) of the integration measures increases.

In competitive markets, it is expected that as DPCP between two markets increases, there will be a price increase in the origin markets as a reflection of the price increase in the destination market. This increases the movement of stocks from surplus to deficit markets. However, DPCP between markets was negative for all measures and significant for the long-run multipliers and the composite index while it was insignificant for the speed of adjustment. The probable reasons for the negative effect of DPCP on market integration could be the result of the problem in the pricing conduct and instability of prices and transaction costs which engenders risk and reduces spatial arbitrage. The instability of prices causes instability of spatial margins thereby decreasing their predictability.

5. Conclusions

This paper has evaluated the level of spatial wheat market integration, the pricing conduct of traders, and the structural determinants of spatial market integration. The analysis was conducted at three stages. First, the various market integration measures were estimated and tested. In the second stage, the pricing conduct of traders in the markets was tested for competitiveness. Finally, the identification of structural factors that determine market integration and estimation of their parameters was conducted. Among other things, it has estimated the dynamics of price relationships and the temporal causation in wheat markets, and has empirically verified that the problem of pricing conduct was prevalent in these markets by explicitly testing for its presence. The major structural factors of market integration were identified and tested for their relative importance in affecting the extent of market integration.

Inter-market price transmission was found to be sluggish in Ethiopian wheat markets for the period specified in the study. The estimated market integration measures and their tests indicate that, in most markets, spatial wheat price adjustment was generally delayed (taking a month and above). This is the result of the lack of competitiveness and flexibility of the agricultural marketing system in the country.

Spatial wheat markets even within 100 kilometers distance did not adjust instantaneously. These markets need one or more months to complete their adjustment to price changes occurred in other nearby markets.

The result indicates that Addis Ababa has a dominant role in fixing prices discriminatively and controlling the price transmission to other supply markets. The underlying assumption of a well-integrated marketing system is its flexibility to transmit prices across different localities (Goletti and Christina-Tsigas, 1995). Prices were discovered in both Addis Ababa and Nazreth but there was no price transmission from Addis Ababa to supply markets. Traders in Addis Ababa respond to the price shocks that are caused in supply markets slowly and protect the price changes within them from transmittal to these markets. This indicates that they work to widen the spatial price differential without sharing it to the producers and the retailers in the supply markets. Nazreth was found to be relatively competitive central wheat market in the discovery and transmission of wheat prices.

The spatial price discrimination in Addis Ababa was the result of the pricing conduct, which, in turn, was the cause for the negative relationship between market integration and DPCP. This is a serious problem for the marketing system in that it creates shortages in destination markets, and surpluses in origin markets. Both consumers in deficit urban markets and producers around surplus markets are, therefore, affected by the problem. The problem of pricing conduct creates a general problem of allocation of resources, if it is not avoided by appropriate legal and marketing measures.

Moreover, four structural factors of market integration were estimated and tested for their effect on spatial price adjustment to identify potential market improvement strategies. The magnitude of market integration and the speed of spatial price adjustment were found to be highly related with the level (size and distribution) of the selected structural factors of integration. The degree of integration and the speed of price adjustment between markets have significant policy implications in that the timing and the location of policy interventions should consider these indicators. Among other things, the following policy implications are derived.

a. The magnitude and speed of price transmission between markets should be improved by developing the determinant structural, institutional, and policy factors of market integration;
b. Spatial pricing conduct problems should be corrected by legal intervention measures to help improve the dynamics of price adjustment process;
c. To formulate cost-effective policy intervention measures and to identify the importance of a commodity in price stabilization process, the empirical knowledge on inter-market and inter-commodity price dynamics should be improved by further studies.

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DECISION-MAKING UNDER RISK: EVIDENCE FROM NORTHERN ETHIOPIA[1]

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Abstract

There is a long standing discussion of whether expected utility theory (EU) or prospect theory (PT) best explains the behavior with respect to risky choices. Often these two approaches are compared by putting questions to students in laboratory situations. Here we try to investigate stated preferences of farmers who are functioning under high levels of risk in real life. As part of a larger survey, four binary choices were offered during two successive years. The experimental test was performed 199 farmers in two districts in Tigray, Northern Ethiopia. Three items were central in comparing the risk attitude according to EU and PT: the asymmetry of risk perceptions, the independence axiom and the shape of the utility function. The farmers in the two different districts (Enderta and Hintalo-Wajerat) differed significantly in their risk attitude. Enderta farmers were significantly risk-averse for gains and risk-seeking for losses; their preferences conformed to the hypothesis of prospect theory. However, expected utility maximization was found to be an appropriate descriptor for Hintalo-Wajerat farmers.

In order to identify the factors that affect farmer's preferences, a binary choice model was used. Household income was found to be positive and significant while value of livestock had the expected negative sign and was directly related to a decrease in risk aversion. Knowledge of farmers' attitude toward risk has important implications for policy makers to devise policies that can overcome the critical constraints they face in meeting their basic needs.

Keywords: risky choice, risk attitude, expected utility, prospect theory, Tigray.

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1 Introduction

In semi-subsistence agriculture, farm households face numerous natural, market and institutional risks in generating means of survival. Yield risk, crop price risk and risk of illness and injuries are important factors that prevail in developing economies. Households have developed various mechanisms for coping with risk. Some of these mechanisms offer short-term protection at long-term cost (e.g. diversification versus specialization). Therefore, their attitude towards risk gives an explanation for their observed economic decisions.

In measuring attitude towards risk, two approaches are identified: econometric and experimental. The econometric approach is based on farmers' actual behavioral data, which typically assumes that farmers maximize the expected utility of income. Given a production technology, the risk associated with production and market conditions, the observed level of input use can reveal the underlying degree of farmers' risk aversion. Examples of this line of research include Bar-Shira *et al*., 1997; Kumbhakar, 2002. The experimental approach is based on questionnaires regarding hypothetical risky alternatives with or without real payments. Here, respondents are asked to choose between lotteries that differ in payoffs, probabilities, or both. The experimental approach is further classified into expected utility and non-expected utility approaches. For example, Binswanger (1981) measured attitude towards risk in rural India. His approach is embedded in expected utility theory. Humphrey and Verschoor (2004) reported an experimental test of individual decision making behavior under risk in rural east Uganda. They found that east Ugandan farmers' risk attitude exhibit systematic deviations from expected utility theory. Binswanger (1981) measured risk attitude to a set of real payments while Humphrey and Verschoor (2004) used real money payments in eight of the twelve decision problems. However, all choice problems were considered as if they were being played for real money (Humphrey and Verschoor, 2004: 67). Real money payments may result in incentive effects and may not reveal the true risk preferences of farmers.

Using the experimental approach without real payments, this paper will identify which choice model best describes risk attitude of Northern Ethiopian subsistence

farmers.[4] The objective of this paper is to measure farmer's attitude toward risk and to see how an individual's attitude toward risk relates to observed characteristics. Specifically, this study seeks to answer: (1) does the expected utility theory explains risk attitude of north Ethiopian farmers better than the non-expected utility approach (such as prospect theory); (2) Are farmers risk-averse to gains and risk-seeking to losses; and are there concave utility shapes for gains and convex utility shapes for losses; (3) Are there systematic differences in attitudes amongst farmers; (4) Is there any evidence to suggest that farmers' socio-economic variables determine aversion to risk. From the research question, it is tested whether or not the farmers made decisions according to the expected utility theory or the non-expected utility theory (prospect theory). Empirical studies on how risk varies across individuals can be useful in predicting households' technology adoption, participation on off-farm work and crop portfolio selection since risk and risk aversion behavior play important roles in these decisions.

In the next section a data set containing farmers' choices of hypothetical binary lotteries are presented. Experimental results on the shape of the utility function and a test of the independence axiom are discussed in section 3. In section 4, factors affecting risk behavior are econometrically determined. Section 5 presents a conclusion.

2 Expected Utility versus Non-expected Utility: Literature Review

2.1 Expected Utility: Background

In general, for several decades the expected utility (EU) model has been dominant in modeling behavior under risk. Von Neumann and Morgenstern (vNM, 1944) are the major contributors to a large body of work that provides the justification for the use of the expected utility model by a rational decision maker. This model views decision making under risk as a choice between alternatives. Decision makers are assumed to have a preference ordering defined over the probability distributions for which the

[4] As the econometric approach is criticized for confounding risk behavior with other factors that are unrelated to risk preferences such as physical constraints and market imperfections (Just and Pope, 2003: 1255). This is particularly important in Ethiopia where market imperfections are prominent.

axioms of the EU model hold (Mas-Colell *et al*., 1995). Risky alternatives can be evaluated under these assumptions using the expected utility function, $U(x)$.

In maximizing the decision maker's utility, consider a risk prospect in which the decision maker does not know ex-ante which state of the world will occur. However, he can list the various alternatives and can attach probabilities to them. For simplicity, assume two possible states of the world, state 1 and state 2, with respective probabilities p1 and p2. Denote x_1 was the individual's monetary gained if state 1 occurs and x_2 if state 2 occurs. The individual must choose ex-ante between the risky bundles (x_1, x_2) . Ex-post, the individual gets x_1 or x_2 depending upon which state of the world has occurred. If the decision maker's preference ordering over risky alternatives satisfies all the axioms of expected utility, including the independence and continuity axioms (see next section), then there exists a vNM expected utility function. This vNM expected utility function reflects the decision maker's choice as if he maximizes utility of the different states weighted by the probabilities for each state to occur.

vNM began by stating that utility maximization is a rational goal when a decision maker is faced with risky choices. In this framework, an individual will evaluate the expected value and objectively given probability of occurrence of each alternative. This evaluation is carried out by first entering the probabilities and expected outcomes into an individual's utility function. It is then a matter of selecting the combination of available alternatives that maximizes the function. The manner in which individuals choose among available alternatives is then dependent upon their utility function. For this setting the vNM expected utility function can be specified as:

$$U(p_1,..,p_i,..,p_N) = \sum_{i=1}^{N} p_i u(x_i) \qquad \textbf{(1)}$$

Where, U is the vNM expected utility function, $u(x_i)$ is the utility of the ith element of a vector of possible outcomes, and p_i is the probability of outcome x_i , $\sum p_i = 1$. The vNM expected utility function $U(p_1,...,p_i,...,p_n)$, defined up to a

positive linear transformation, characterizes both the utility of the outcome and the individual's attitude toward risk. The curvature of this utility function contains information about the degree of individual's risk aversion (Mas-Colell *et al*., 1995: 173).

Axioms of the expected utility theory

There are three main axioms in the expected utility framework. They are defined over a binary relation where:

$\succeq$ denotes weak preference,

$\succ$ denotes strict preference, and

~ denotes indifference.

For preferences over probability distributions $p,q,r \in P$ that are defined over a common (discrete or continuous) outcome vector X . The three axioms that are necessary and sufficient for the expected utility representation $U(\cdot)$ over preferences are:

Axiom O (Order):

The binary relation $\succ$ on P is asymmetric and transitive. The asymmetric part of axiom O says that the decision maker will not both prefer p to q and prefer q to p . According to expected utility theory, it is irrational to hold a definite preference for p over q and a definite preference for q over p at a time. However, there is a possibility that neither p nor q is preferred (i.e. $p \sim q$, the decision maker is indifferent between p and q).

The transitivity part of axiom O holds if and only if both $\succ$ and ~are transitive, i.e., for all $p,q,r \in P$, ($p \succeq q$, and $q \succeq r$) $\Rightarrow p \succeq r$; ($p \sim q$ and $q \sim r$) $\Rightarrow p \sim r$. Transitivity implies that it is impossible to face the decision maker with a sequence of pair wise choices in which preferences appear to cycle. For example, a decision maker feels that an apple is at least as good as a banana and that a banana is at least as good as an orange but then also prefers an orange over an apple.

Axiom C (Continuity):

For all $p,q,r \in P$ with $p \succeq q$ and $q \succeq r$ there exists $\alpha, \beta \in (0,1)$ such that: $\alpha p + (1-\alpha) r \succeq q$ and $q \succeq \beta p + (1-\beta) r$. This axiom gives continuity to the preferences. Continuity means that small changes in probabilities do not change the nature of the ordering between two lotteries (see Mas-Colell *et al.*, 1995: 171). Continuity rules out lexicographic preferences.

Axiom I (Independence):

For all $p,q,r \in P$ and for all $\alpha \in (0,1)$, if $p \succeq q$, then $\alpha p + (1-\alpha) r \succeq \alpha q + (1-\alpha) r$. This axiom states that preferences over probability distributions should only depend on the portions of the distributions that differ (p and q) and not on their common elements (r) and of the level of α that defines the linear combination. In other words, if we mix each of two lotteries with a third one, then the preference ordering of the two resulting mixtures does not depend on the particular third lottery used.

Axioms O, C, and I can be shown to be necessary and sufficient for the existence of a function $U(\cdot)$ on the outcomes $x \in X$ that represents preferences through $\succeq$. The role of the order, completeness and continuity axioms are essential to establish the existence of a continuous preference function over probability distributions. It is the independence axiom which gives the theory its empirical content and power in determining rational behavior. That is, the preference function is constrained to be a linear function over the set of probability distribution functions, i.e. linear in probabilities (Machina, 1982: 278).

If an individual obeys the expected utility axioms, then a utility function can be formulated that reflects the individual preferences (Mas-Colell *et al.*, 1995: 175; Robison and *et al.*, 1984: 13). Further individual's risk attitude can be inferred from the shape of his/her utility function. Since vNM (1944), the expected utility model has been the dominant model in predicting choice behavior under risk. Starting with the well-known paradox of Allais (1953), however, a large body of experimental evidence has been documented which indicates that individuals tend to violate the axioms underlying the expected utility model systematically. This empirical evidence has motivated researchers to develop alternative theories of choice under risk able to accommodate the observed patterns of behavior. A wave of theories designed to

explain the violation of expected utility theory began to emerge at the end of the 1970. Examples are prospect theory (Kahneman and Tversky, 1979), regret theory (Loomes and Sugden, 1982), dual theory (Yaari, 1987), cumulative prospect theory (Tversky and Kahneman, 1992), and rank-dependent utility (Quiggin, 1993). For a thorough review see Starmer (2000). In the empirical literature, prospect theory is the dominant theory. Therefore, it will be discussed in section 2.2.

2.1.1. Violation of the independence axiom

The common consequence effect. The well-known risky choice provided by Allais is given in a paper by Kahneman and Tversky (1979). They synthesize the work by Allais and by others who have shown experimental violations of expected utility. The Allais paradox depicted in Table1 is the leading example of this class of anomalies. There are two different choice sets, for each choice set there are two lotteries from which you can choose. For example, in lottery A1 there is a guaranteed payoff of \$1M and zero probability of winning nothing. In lottery A2, there is a 0.10 probability of winning \$5M, a 0.89 probability of winning \$1M, and a 0.01 probability of winning nothing. Then one has to choose between A1 and A2, and between A3 and A4. Where A_1, A_2, A_3, A_4 are lotteries.

Table 1: The Allais paradox: the common consequence effect

Choice 1	A1	{1 M, 1; 0 M, 0}	A2	{5 M, 0.1; 1 M, 0.89; 0 M, 0.01}
Choice 2	A3	{5 M, 0.1; 0 M, 0.9}	A4	{1 M, 0.11; 0 M, 0.89}

Note outcomes are in Dollars and 1M = \$1,000,000.

Many agents prefer lottery A1 to A2 and prefer lottery A3 to A4. This empirical tendency directly contradicts expected utility theory. According to expected utility theory $A1 \succ A2$ if and only if $1u(\$1M) > 0.10u(\$5M) + 0.89u(\$1M) + u0.01u(\$0)$. Subtracting $0.89u(\$1M)$ from each side, it follows that $0.11u(\$1M) > 0.10u(\$5M) + 0.01u(\$0)$. Adding $0.89u(\$0)$ to both sides, we have $0.11u(\$1M) + 0.89u(\$0) > 0.10u((\$5M) + 0.90u(\$0)$ which holds if and only if $A4 \succ A3$. Thus, from expected utility theory, one can deduce that

$A1 \succ A2 \Leftrightarrow A4 \succ A3$. However, many people choose $A1$ over $A2$ and prefer $A3$ over $A4$. This pattern of choice violates the independence axiom and hence the expected utility theory. The Allais Paradox is now commonly known as a special case of a general empirical pattern called the common consequence effect. The name comes from the "common consequence" 1M in gamble 1 and 0 in gamble 2. The independence axiom requires that preferences be unaffected by changes in a common consequences. The Allais Paradox demonstrates that individuals are sensitive to shifts in probability mass. According to the independence axiom, an individual's preferences in one event should not depend on the outcome in another event. Thus, it can be shown that violation of the independence axiom explains the observed inconsistencies in the measurement of the vNM utility model. If an agent is an expected utility maximizer then he must prefer A1 to A2 and A4 to A3. Agents may prefer A1 to A2 because they like to be a millionaire with certainty, implying risk aversion. But in choice set 2, the gambles are quite different with a high probability in each lottery of not winning any money. So, the agent may simply choose A3 because the chance of winning \$5M is very similar to the chance of winning \$1M and \$5M is much more. The typical agent responds in a more risk-averse manner in choice set 1 and more risk neutral in choice set 2.

2.1.2. Violation of the Order Axiom

In addition to the violation of the independence axiom, there is experimental evidence suggesting that descriptive failures of expected utility may run deeper than violations of the independence axiom (Starmer 2000: 338). The two hidden assumptions in any conventional theory of choice are procedure invariance and descriptive invariance, which constitute another source of weak descriptive power for expected utility. Procedure invariance suggests that preferences over prospects and acts are independent of the method used to elicit them. However, description invariance stipulates that preferences over prospects are purely a function of the probability distributions and do not depend on how these objects are described.

The most serious blow for the procedure invariance assumption may have been the discovery of preference reversal. Preference reversal, first reported by Lichtenstein and Slovic (1971), describes experimental results that appear to indicate systematic violations of transitivity of preferences. In their experiment, subjects were asked to

choose between two bets and then to give their true certainty equivalents for the bets in the form of a selling and a buying price. In many cases the subjects set the lowest price for the preferred lottery. In other words, individuals were presented with two gambles, one featuring a high probability of winning a modest sum of money (the P bet), the other featuring a low probability of winning a large amount of money (the $ bet). The typical finding is that people often choose the P-bet but assign a larger monetary value to the $-bet. In their 1971 article, Lichtenstein and Slovic presented the following pair of gambles (see Table 2).

Table 2: Preference reversal bets

P-bet	{$4, 0.99; -$1, 0.01}	Expected outcome of the P-bet = $3.95
$-bet	{$16, 0.33; -$2, 0.67}	Expected outcome of the $-bet = $3.94

The P-bet says that there is a 99 percent chance of winning $4 and a 1 percent chance of losing $1. The $-bet says that there is a 33 percent chance of winning $16 and a 67 percent chance of losing $2. Expected outcomes of the two lotteries are almost the same. The subjects were asked to choose which game they would like to play. Later they were told that they had the ticket to play the bet and were asked to name a minimum selling price for the ticket. Lichtenstein and Slovic found that 73% of the participants consistently have a higher price to the $-bet even though they had chosen the P-bet. The EU theory implies that the bet which is actually chosen will be the one assigned the largest selling or buying price. In an earlier study, Slovic and Lichtenstein (1963) observed that choices among pairs of gambles appeared to be influenced primarily by probabilities of winning and losing. On the other hand, buying and selling prices were more highly correlated with payoffs than with probability of winning. Following this observation they argue that if the method used to elicit preferences affected the weighing of the gamble's components, it should be possible to construct pairs of gambles such that the same individual would choose one member of the pair but set a higher price for the other. When viewed from the standard theory perspective, this gamble presents a puzzle. Both choices constitute ways of asking essentially the same question. However, the ordering revealed in these experiments appears to depend upon the elicitation procedures. Moreover, choice and valuation tasks may invoke a different mental process, which in turn generates different ordering of a given pair of prospects. Consequently, the

ranking observed in choice tasks cannot be explained with reference to a single preference ordering (Starmer, 2000: 338).

2.2 The Non-expected Utility Model: Prospect Theory

As mentioned earlier the most commonly accepted model of decision making under risk is the expected utility theory. In the late 1970s, the completeness of EU theory in explaining behavior was challenged. These challenges give rise to the development of competing theories that attempt to explain individual behavior under risk. This section presents one of these alternative theories: prospect theory (PT).

PT was first developed by Kahneman and Tversky (1979). They developed their theory as an alternative to expected utility theory for explaining the outcomes of individual decision making under risk. They argue that the choices individuals make in risky situations exhibit several characteristics that are inconsistent with the basic axioms of expected utility theory. They argued that individuals under-weigh probable outcomes in comparison with outcomes that are certain; they called this phenomenon the certainty effect. They also pointed out that the certainty effect brings about risk-aversion in choices involving certain gains and brings about risk-seeking in choices involving certain losses (Kahneman and Tversky, 1979).

Kahneman and Tversky (1979) distinguished two sequential phases in a decision process: the editing phase and the evaluation phase. In the editing phase, decision makers contemplate the choice situation and, if possible, simplify the problem. This includes the operation of coding. That is, outcomes are coded as gains or losses; prospects are simplified by combining probabilities associated with identical outcomes; risky components of a prospect are separated from the risk-less components of the prospect; and finally, components of choices common to all prospects are discarded. The edited prospects are then evaluated and the most highly valued risky outcome is chosen. Prospect theory employs two functions: a probability weighing function $\pi(p)$, and a value function $v(x)$. These functions are combined to form the basic equation of the theory which determines the overall value of a prospect. Following is the equation that Kahneman and Tversky (1979)

used for simple prospects with the form $(x, p; y, q)$, a gamble between two outcomes (x, y) with associated probabilities (p, q) which has at most two nonzero outcomes:

$$V(x, p; y, q) = \pi(p)v(x) + \pi(q)v(y) \quad \textbf{(2)}$$

When the prospects are strictly positive or negative, the evaluation follows a different rule. In the editing phase the prospects are separated into a risk less (the minimum gain or loss which is certain to be gained or paid) and a risky component (the additional gain or loss which is actually at stake). Thus, if $p + q = 1$ and either $x > y > 0$ or $x < y < 0$, so $\pi(q) = [1 - \pi(p)]$, then,

$$V(x, p; y, q) = v(y) + \pi(p)[v(x) - v(y)] \quad \textbf{(3)}$$

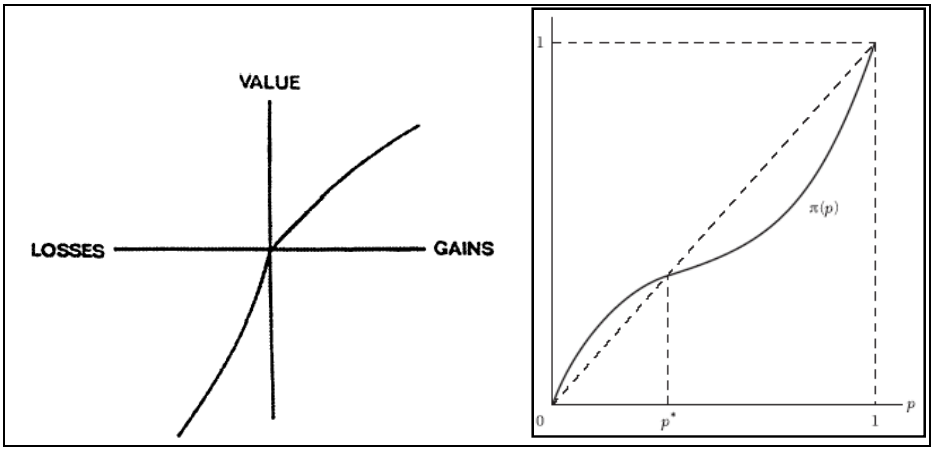
One of the essential features of prospect theory is that the overall value of a prospect is based on changes in a decision-maker's wealth reference point rather than on final wealth states, as in the case of the EU theory. Kahneman and Tversky propose the value function, one of the most widely used components of prospect theory, a function that is commonly S-shaped. It is generally concave for gains (implying risk aversion), convex for losses (implying risk-seeking), and steeper for losses than for gains (see Figure 1).

Another major departure of prospect theory from the EU theory is the treatment of the probabilities. In EU models, the uncertain outcome is weighed by its probability, the uncertain outcome in prospect theory is multiplied by the decision weight $\pi(p)$. The weighing function, π, which relates decision weights to stated probabilities, is a monotonic function of p, with $\pi(0) = 0$ and $\pi(1) = 1$, but is not a probability and should not be interpreted as a measure of degree of belief.

According to prospect theory, very low probabilities are over-weighed, that is, the decision weight attached to the rare event is larger than the probability $\pi(p) > p$. Furthermore, prospect theory suggests that for all $0 < p < 1, \pi(p) + \pi(1 - p) < 1$, this is sub-certainty. It implies that as low probabilities are over-weighted, moderate

and high probabilities are underweighted. That is the decision weight is smaller than the probability $\pi(p) < p$.

Figure 1: A hypothetical value function and a weighting function (Kahneman and Tversky, 1979: 279)



As in the EU model, values and weights are combined in prospect theory. Outcomes transferred into values by the value function, are weighed by the decision weights and then summed. This summed index is used to rank probability distributions; the subject is assumed to choose the distribution with the highest index (Smidts, 1990). Consider, the choice between the gamble $(x, p; y, q)$, a gamble between two outcomes (x, y) with associated probabilities (p, q). In expected utility maximization theory the value of the utility function is $U(X) = pu(x) + qu(y)$ and in prospect theory, the value function is a $V(X) = \pi(p)v(x) + \pi(q)v(y)$. In both cases, the summed function is maximized and the highest value is chosen. Prospect theory and EU theory coincide when $\pi(p) = p$ for all p and when $u(x) = v(x)$. In this case, the expected utility of a lottery defined on $U(X)$ equals the value $V(X)$ of the gamble in prospect theory.

It can be concluded that prospect theory seems much more descriptive than expected utility theory. Prospect theory is capable of explaining decisions that expected utility theory is incapable of explaining. For example, expected utility

theory cannot account for certainty gains, such as the certainty effect that may have a strong influence on individual's decision preferences.

3 Data Collection Methodology and Description

Risk assessment data were collected for two years (2001 and 2002) from Tigray, northern Ethiopia. The respondents also participated in a survey on crop production, labor allocation, and consumption decisions. The questionnaire was framed as a farm decision problem and the respondents were the head of their household. In 2001, two hypothetical questions were asked: one question without loss and the other question with loss. The same hypothetical questions from 2001 were also asked in 2002. The purpose of this was to stimulate the actual process of decision making and to see whether there is a learning effect in the decision process. Seven additional questions were asked in 2002, which did not involve loss (for details of the questions asked and description of the experimental designs see Appendix I and Appendix II). It is assumed that farmers' choice between the binary hypothetical outcomes was taken as an indication of his/her risk attitude behavior. The two hypothetical questions consisted of two possible outcomes with given objective probabilities; the respondents were asked to state which of the two options (s)he prefers. It was mentioned that there was no right or wrong answers to these questions. In each year, a total of 199 households participated. It is assumed that by answering the hypothetical questions farmers exhibited their true preferences.

All outcomes of the hypothetical questions are in Ethiopian Birr.[5] For example, in choice 1, the choice is between the safest (certain) option S1 and the riskier option R1 (the probabilistic gain option).[6] The mean is the expected monetary value of the lottery and its standard deviation is denoted by SD. In all of the choice problems, the expected mean value of the riskier option is higher than the safest option. This can be considered as a control for the behavior of risk-aversion of experimental subjects. Accordingly, each decision problem is considered as a choice between a relatively safe and a relatively risky alternative. It can also be considered that the low variance

[5] Ethiopian Birr is a local currency with exchange rate as of 2005 is 1$=8.66 Ethiopian Birr.

[6] In this study safest option means a lottery with lower expected mean value but higher probability of winning the lottery. Riskier option means a lottery with higher expected mean and low probability of winning the lottery.

choice is the safer option and the high variance choice is the riskier option.[7] Farmers opting for the safe option are called more risk-averse than farmers who choose the risky option. The percentage of farmers choosing the safest option for each choice is presented below. For choice 1, most of the respondents choose the certain gain rather than the gamble of the certainty effect. Farmers who choose the gamble show risk-seeking behavior while those who choose the certain outcome show risk-averse behavior.

Choice patterns of farmers in the year 2001 and 2002

Table 3: Choice 1

	Proportion safest choice chosen		Safest option: S1		Riskier option: R1	
	2001	**2002**	**Mean**	**SD**	**Mean**	**SD**
S1: (500,1) vs. R1: (1000,0.75) [8]	83.42	81.41	500	0	750	433

Choice 1 (S1) offered a 100 percent chance of receiving 500 Birr while R1 offers a 75 percent chance of receiving 1000 Birr. The expected value for lottery S1 is 500 Birr with standard deviation zero. For lottery R1 the expected mean is 750 Birr with a standard deviation of 433. Thus, the two lotteries have a relatively large difference in expected values. More than 80 percent of the farmers chose the safest choice in both years (year 2001 and 2002). When farmers are confronted with the sure gain and probability gain, they tend to choose the sure gain rather than the probability gain. Roughly an equal number of farmers chose the sure gain in 2001 and 2002, as choice problem 1 involves no losses.

[7] The measure of variability used is the variance of outcomes around the expected mean value.

[8] (x, p) denotes the hypothetical gain x with corresponding probability p .

Table 4: Choice 2

	Proportion safest choice chosen		Safest option: S2		Riskier option: R2	
	2001	2002	Mean	SD	Mean	SD
S2: (-500, 1) vs. R2: (-1000,0.75)	49.75	56.78	-500	0	-750	433

Choice 2 is the opposite of choice 1; the sign is reversed so that gains are replaced by losses. Table 4 shows that almost half of the farmers choose the sure loss in both years. The mean equality test for the choices occurring in both years indicates that there is no significant difference in means (t=0.52). This choice pattern implies that farmers' preference between negative prospects is not the mirror image of the preference between positive prospects. This finding is in contrast with most of the findings of laboratory experimental studies with students as subjects (e.g. Kahnemans and Tversky, 1979).

Choice patterns in the year 2002

Table 5: Choice 3

	Proportion safest choice chosen	Safest option: S3		Riskier option: R3	
		Mean	SD	Mean	SD
R3: (5000,0.25) vs. S3: (2000,0.50)	51.3	1000	1000	1250	2165

In choice 3, about half of the farmers chose the safest choice. Here the safest choice has an expected value of 1000 Ethiopian Birr with a probability of winning equal to 50 percent. The riskier option has an expected mean of 1250 with a probability of 25 percent. It seems that half of the sample farmers exhibit risk-seeking behavior; they opt for the gamble rather than for the safest choice.

Table 6: Choice 4

	Proportion of safest choice	Safest option: S4		Riskier option: R4	
		Mean	SD	Mean	SD
R4:(9000,0.50) vs.S4: (4500,0.75)	48.7	3375	1949	4500	4500

Similar to choice 3, almost half of the farmers in choice 4, chose the riskier option. In choice 4, the safest choice has low variance (with standard deviation 1949) when compared to the riskier option (with standard deviation 4500). In this choice set, about 48.7% of farmers chose the safest choice. However, more than half of the subjects opt for the riskier option, suggesting that they were more risk-lover in this choice set.

4. Test of the Expected Utility Axiom

4.1 Test on the Shape of the Utility Function

Table 7 presents the proportion of choice in the gain and loss domain of the utility function; 82% of choices significantly reflect a concave shape for gains. That is, Tigray farmers are very attracted to a sure gain compared to risky prospects, which risk-averse behavior (the certainty effect).[9] Furthermore the result for gains confirmed that the utility function is concave implying that the utility function has a diminishing marginal utility, which is also a well-known empirical finding in the agricultural economics literature. In Enderta and Hintalo-Wajerat, 89% and 76% of subjects respectively were classified as showing a concave utility for gains. Thus, was a significantly larger proportion of respondents classified as being concave than convex (the proportion is significant at 5% significance level). In these tests, the null hypothesis states that a concave classification is at least as likely as a convex classification; tests are therefore two-tailed. As the experimental procedure in elicitation of utility did not use certainty equivalent procedures, linear classifications were not treated here.

[9] The result is consistent with the findings of Humphrey and Verschoor, 2004.

Table 7: Percentage of concave and convex parts for gains and losses [choice1 vs. choice2]

	Gains			Losses		
	Full Sample	**2001**	**2002**	**Full Sample**	**2001**	**2002**
Enderta						
Concave	89	96	82	36	20	52
Convex	11	4	18	64	78	48
Hintalo-Wajerat						
Concave	76	71	81	71	79	62
Convex	24	29	19	29	21	38
Total Sample						
Concave	82	83	81	53	50	57
Convex	18	17	19	47	50	43

The utility shape for losses was also identified; the finding in this case is mixed. In Enderta, about 64% of subjects exhibit a convex utility function for losses. This empirical finding is consistent with most of the findings in psychological studies. It says that losses loom larger than gains so that people display loss aversion in the domain of losses, resulting in a utility function that is steeper for losses than for gains. Thus Enderta farmers can be classified as a risk-taking behavior over losses so that a risky loss is preferred to a certain one (i.e. they tend to choose the gamble rather than the sure loss). However, in Hintalo-Wajerat a significant proportion (about 71%) of subjects exhibit concave utility for losses. Hintalo-Wajerat farmers' utility function for losses is concave rather than convex. This finding is not in accordance with the prospect theory, in that an individual's value function is convex in losses and much more sensitive to certain losses than to a risky loss. However, Hintalo-Wajerat farmers preferred a certain loss to a risky loss. Therefore, loss aversion would not help in explaining Hintalo-Wajerat farmers' behavior.

In Hintalo-Wajerat, the experimental evidence revealed that subjects are increasingly inclined to select the safe choice in the domain of gains, while the opposite happens in the loss domain (more subjects are inclined to be more risk seeking in 2002 than in 2001). Subjects might realize that the riskier option has a

higher expected value than the safer option and become more risk-seeking in the loss domain. This is contrary to what an expected utility maximization would prescribe. In Enderta, the choice is more stable and consistent in the gain domain. However, in the loss domain more subjects' choices converge to a utility maximization hypothesis in the year 2002.

4.2 Test on the Independence Axiom

The independence axiom of the expected utility theory requires that if a person chooses a safe option in the gain domain, he must also choose the safe option in the loss domain. If this does not hold, the expected utility theory will be violated. To test the independence axiom we only used Choice set 1 and Choice set 2 (see Appendix I for details of the choices offered to farmers).

Table 8 reports the result of choice for the independence axiom. SS and RR choice responses are consistent with expected utility theory whereas RS and SR choice responses are not (SS response denote the safer S option being chosen in both the first and second choice and RR response denotes the riskier option being chosen in both the first and the second choice problems). In this test, the null hypothesis states that the proportion of choice consistent with expected utility maximization (i.e., SS and RR choice) is equal to the proportion of choice to the prospect theory maximization (SR and RS).

Table 8: Proportion of choice responses in the lottery pair (choice 1 vs. choice 2)

	Enderta (n=99)					Hintalo-Wajerat (n=100)				
	SS	**RR**	**SR**	**RS**	**p-value**	**SS**	**RR**	**SR**	**RS**	**p-value**
2001	**19**	**3**	**76**	**1**	**0.00(z=-7.82)**	**58**	**8**	**13**	**21**	**0.000(z=4.53)**
2002	**46**	**13**	**35**	**5**	**0.007(z=2.70)**	**51**	**8**	**31**	**10**	**0.011(z=2.55)**

Table 9 clearly shows that in Enderta and Hintalo-Wajerat, 40% and 63% of choice responses are consistent with expected utility theory. In Enderta, subjects chose the sure gain rather than the risky gain in the first choice problem. In the second choice problem, subjects preferred the risky loss rather than the sure one in 2001 and 2002. About 79% and 41% of choices in Enderta are not consistent with expected

utility maximization. There is a significant difference of choice proportions between 2001 and 2002. Learning effects, market factors, and environmental factors might explain the difference. In Hintalo-Wajerat, although the choice in 2002 reveals slightly more violations than in 2001, the independence axiom does seem to hold.

Table 9: Summary proportion of choice consistent with expected utility theory

	Full Sample	2001	2002
Enderta	40	21	59
Hintalo-Wajerat	63	66	59
Total sample	51.5	44.22	58.79

Furthermore, Table 9 reports that 37% of subjects' responses are contradictory with the expected utility maximization theory in Hintalo-Wajerat. The majority of choice responses are consistent with expected utility theory. Therefore, the expected utility model would be the best descriptor of decision behavior under risk for Hintalo-Wajerat farmers. Moreover, the difference between the proportions of expected utility theory choices in Enderta and Hintalo-Wajerat is significant at the 5% level (t=2.48 with a two-tailed test of a difference in sample proportions based on the normal distribution). It appears that the difference is primarily driven by a higher proportion of risk-averse behavior (i.e., choosing the safest option in both choice problems) in Hintalo-Wajerat than in Enderta (there is a higher proportion of relatively risk-seeking behavior SR in Enderta). Thus, expected utility theory does appear to be an appropriate descriptor of risky choices made by rural households in Hintalo-Wajerat. However, in Enderta, the result suggests that risk aversion may be an appropriate assumption in the domain of gains and risk-seeking in the domain of losses.

5. Factors Affecting the Risk Attitude of Farmers

It was shown that almost all of the farmers surveyed were risk-averse; they chose the safest choice options (see choice 2 to choice 4 in Appendix II). Here, it is important to know the factors that influence farmers' risk attitude. Defining the set of factors that influence risk attitudes is difficult, since many are part of the psychological makeup of the individual. However, there are several observable physical and economic factors that might influence risk attitudes (Grisley and Kellog, 1987).

Empirical model

In order to identify the factors that affect farmers' preferences a binary choice model was used. When several continuous variables are used as explanatory variables in only one choice, then estimating a *logit* model is necessary (Pindyck and Rubinfeld, 1998: 312). Therefore, the proportion of choices favoring the safest option is regressed on household specific characteristics. The model takes the form:

$$P(SC = 1/x) = \frac{\exp(\beta x_i)}{1 + \sum \exp(\beta x_i)} = x_i'\beta + \varepsilon \qquad \textbf{(4)}^{10}$$

where x is a $1 \times k$ matrix of explanatory variables pertaining to observation i, $P(SC = 1/x)$ is the probability that the safest choice is chosen given the full set of explanatory variables x that influence the choice [such as age of the head, gender, family size, and total household income (off-farm and farm income)]. SC is the qualitative variable that indexed the safest choice with $SC = 1$ indicating that the safest choice has been chosen, and $SC = 0$ indicating that the safest choice is not chosen. β is a $k \times 1$ vector of parameters, ε is an error term having a logistic distribution.

The probability model of equation (4) can take the form:

$$P(SC/x_i) = 0(1 - (x_i'\beta)) + 1((x_i'\beta)) = x_i'\beta + \varepsilon \qquad \textbf{(5)}$$

Because the sign and magnitude of the estimated coefficients are relative to the response probability, direct estimation of the binary choice model is difficult. It is often more insightful to estimate the marginal effects of changes in the independent variables on the probabilities of choosing the safest option (Greene, 2003: 668; Long and Freese, 2003: 139). The marginal effects of changes in each of the k independent variables can be calculated and used to map the impacts on the probability space.

[10] P(.) is non-linearly related to $x_i'\beta + \varepsilon$. This means that the ordinary least square (OLS) procedure cannot be used to estimate the parameters (Judge *et al*., 1982).

$$\frac{\partial P(SC/x)}{\partial x_k} = (x_i'\beta)((1-(x_i'\beta))\beta \qquad \textbf{(6)}$$

The dependent variable is a dummy indicating whether the safest choice is chosen.[11] The dependent variables are household head characteristics (age and education), household size, household wealth (value of livestock including cattle, camel, horses, mules, donkey, sheep and goat), year dummy, district dummy and mean district 10-year rainfall. Household size is measured by the number of persons living in the household for at least 9 out of 12 months. Household age is measured as completed years. Head education is a dummy indicating whether the household head is literate. Year dummy captures the differences in rainfall between 2001 and 2002. District dummy captures differences in access to markets and other district characteristics. The descriptive statistics of variables are presented in Appendix 4 III.

Estimation Results[12]

The results are presented in Table 10, which includes the values of the logit estimated coefficients, t-statistics, and marginal coefficients. None of the household head characteristics (age and education) are significant influences on risk attitude behavior. It is often assumed that older people are more risk-averse, numerous studies have confirmed this. In this study neither age nor education of the household head, predicts risk preferences. Moreover, the insignificant results obtained for the household characteristics indicate that these variables may not be exogenous in determining household's risk preferences. The wealth variable (livestock value) is significantly and negatively associated with the safest choice. This result is in line with many empirical findings which confirmed that wealthier households are more likely to undertake risky activities (Rosenzweig and Binswanger, 1993). The expectation that wealthier groups should be more risk

[11] If the respondents choose the safest choice in one of the four choices, then *SC* takes the value of 1.

[12] The unrestricted log-likelihood for the *logit* model is -244.01. the Chi-squared statistic is, therefore, 53.07. The critical value from the chi-squared distribution with 8 degrees of freedom is 15.51, so the null hypothesis that all slope coefficients are zero is rejected at 5 percent significance level..

taking is supported, but not significantly. The result is consistent with Yesuf (2004), who found negative correlations between wealth and risk aversion.

Table 10: Estimation results and marginal effects of the probability of choosing the safest option

	Coefficient	z-value	Marginal effect
Intercept	-2.02*	-2.30	
Head age	-0.00	-0.01	-0.00
Head education dummy	-0.29	-1.16	-0.06
Family size	0.02	0.34	0.01
Value of livestock	-0.08*	-2.11	-0.02
District dummy (Enderta=1)	-0.74**	-2.98	-0.14
Year dummy (2001=1)	-2.13***	-4.19	-0.48
District mean rainfall	0.04***	3.64	0.01
Log likelihood	-244.01		
LR chi2(8)	53.07***		
Number of observation	398		

*Significant at 0.05 significance level; ** significant at 0.01 significance level; *** significance at 0.001 significance level.

The district dummy significantly affects risk-aversion behavior. This result confirms our expectations because Enderta is better-off than Hintalo-Wajerat with respect to the annual precipitation amount, access to markets, etc. The results suggest that farmers in Enderta are more risk-loving than farmers in Hintalo-Wajerat. Finally, the most important variable that predicts risk preferences is the 10 year mean rainfall and year dummy. The year dummy is a good predictor of risky behavior. Since 2001 was a good harvest year, households had more risk-taking behavior in 2001 than in 2002.

6. Discussion and Conclusions

In this paper we used experimental data from Enderta and Hintalo-Wajerat districts in Tigray. A set of hypothetical questions on lotteries were asked to farmers. Using the answers to these hypothetical lottery questions, we investigated: (1) whether farmer's preferences are consistent with expected utility theory or prospect theory, (2) whether farmers are risk-averse to gains and risk-seeking to losses, and have concave utility for gains and convex utility for losses, and (3) whether there is any relationship between farmers' socio-economic variables and preferences. In the experiment it is said that farmers opting for the safe option are called more risk-averse than farmer who choose the risky option.

The result indicates that more than 80 percent of the farmers chose the safest choice. When farmers are confronted with sure gain and probability gain, they tend to choose sure gain; this is the certainty effect. However, when farmers' are confronted with sure loss and probabilistic loss, about 53 percent of farmers choose the safest choice (i.e., the sure loss). This finding is in contradiction with the findings of Kahneman and Tversky (1979). With respect to the shape of the utility function the finding is mixed. In Enderta about 64 percent of the subjects exhibit a convex utility for losses. This finding is consistent with most of the psychology literature findings. Prospect theory or loss-averse behavior is the appropriate model for explaining Enderta farmers' risk attitude. While in Hintalo-Wajerat a significant proportion of choice (about 71%) of the subject exhibit concave utility for losses. This is in contrast to what prospect theory suggests. Here, expected utility maximization would be the appropriate model in explaining and modeling Hintalo-Wajerat farmers' risk preferences. None of the household head characteristics (age and education) are significant influences on risk attitude behavior of Tigray farm household heads. District dummy, ten years mean rainfall, and household income significantly influence risk preferences of farmers.

Knowing and understanding the behavior of individual farmers' attitude toward risk would enable policy makers to devise policies that can overcome some of the critical constraints they now face in meeting their basic needs.

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Appendix I: The type of hypothetical questions offered to the farmer

Choice1. If you are given the choice between A and B which option would you select?

1. A sure gain of Birr 500.
2. A risky prospect that offers a 75 percent chance of winning Birr 1000 and a 25 percent chance of winning nothing.

Choice2. If you are given the choice between A and B which option would you select?

1. A sure loss of Birr 500.
2. A risky prospect that offers a 75 percent chance of losing Birr 1000 and a 25 percent chance of losing nothing

Choice3. If you are given the choice between A and B which option would you select?

1. A sure gain of Birr 2000
2. A risky prospect that offers a 25 percent chance of winning 5000 Birr, a 50 percent chance of winning 2000 and a 25 percent chance of winning nothing.

Choice4. If you are given the choice between A and B which option would you select?

1. A risky prospect that offers a 25 percent chance of winning 5000 Birr and a 75 percent chance of winning nothing.
2. A risky prospect that offers a 50 percent chance of winning 2000 Birr and a 50 percent chance of winning nothing.

Appendix II Experimental Design and questionnaire

A hypothetical questionnaire was developed using 25 test interviews to ensure that the hypothetical questions would be interpreted correctly. All the interviewers had prior experience and received two days training. Because of their district background and two time contact with the farm households, we believe that the effect of interviewer bias could be minimized. In the experiment, subjects were offered with four sets of hypothetical choice, involving no real money payment (see Appendix I). A total of 398 subjects participated in the experiments. To minimize the order effects, the hypothetical questions were randomly arranged and randomly offered to the respondents. The hypothetical questions offered can best be understood by examining the pair of lotteries in Table 1.

Table 1: Descriptive statistics of proportion of choice response in the lottery pairs by year.

Questions	Proportion safest		Safest Option		Riskiest Option	
	2001	2002	Mean	SD	Mean	SD
Choice1 S1: (500,1) vs. R1: (1000,0.75)	83.4	81.4	500	0	750	433
Choice2 S2: (-500, 1) vs. R2: (-1000,0.75)	49.7	56.8	-500	0	-750	433
Choice3 S3: (2000,1) vs. R3: (5000,0.25; 2000,0.50)		77.4	2000	0	2250	1785
Choice4 R4: (5000,0.25) vs. S4: (2000,0.50)		51.3	1000	1000	1250	2165

Note: (x, p) denotes the hypothetical gains x with corresponding probability p and zero otherwise.

As indicated in the data description section of this paper, S and R correspond to the safest and riskier choice respectively. We call the low variance lottery the safe option and the high variance lottery as the risky option. For example in the year 2001 about 83.4% of subjects chose the safest option.

Appendix III. Descriptive statistics of household characteristics

Variables	Mean	Standard deviation	Min	Max
Age of head	51.82	11.90	22	83
Family size	5.95	2.19	1	11
Head education dummy (=1 if literate)	0.37	0.48	0	1
Value of livestock	3596.94	3941.48	0	25200

THE DYNAMIC LINKS BETWEEN INVESTMENT, TRADE AND GROWTH: EVIDENCE FROM ETHIOPIA[1]

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Abstract

The existing pool of evidence on the growth effects of investment and trade, as well as the reciprocal effects, is hardly sufficient, rendering their connections to remain inconclusive. The insufficiency of such studies is chronic when it comes to the Ethiopian economy. The investment, trade and growth connections in the Ethiopian economy have not been well researched, calling for such kinds of studies. Targeting at characterising the patterns of impact flows between investment, trade and growth in Ethiopia and contributing a little in filling some aspects of the lacuna, this study becomes a short-run causality analyses on their dynamic links using time series data over the period 1955-2003. According to the estimated VAR results, there is no feedback between any pair of the variables, out of the 3 hypothesised dynamic feedback links. Nonetheless, we have observed two uni-directional positive causalities that run from economic growth to enhanced trade openness and from the latter to investment. However, the evidence should not be interpreted as investment and trade do not contribute to growth. Rather, it could be signalling the low investment and trade performances of the country despite the unknown minimum thresholds of the rate of investment and trade openness for their respective impacts to be recognizable. Hence, measures that improve the performance of both activities, their linkages and the contribution of trade to investment could help the economy to build its productive capacity and then to grow faster.

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1. Introduction

Economic growth often refers to improvements in the main economic performance measures that ultimately improve the wellbeing of a nation. The term economic growth often represents the increase or growth of a specific performance measure such as GDP or Per Capita GDP. La Grandville (2009) defines economic growth simply as an increase of income per person (P. 29). Economic growth can also be seen as the expansion of the productive capacity of a nation.

Growth performances vary greatly across the world due to several reasons. As emphasised in many empirical growth studies, factors that contribute to the cross-country growth differences include a set of quantifiable variables such as the initial level of income, rate of investment, human capital, government activities, demographic factors like population growth or rate of fertility, policies, the rule of law, macroeconomic stability, changes in terms of trade and openness to trade, institutions, etc (see Barro, 2003, P. 231, Thrilwall, 2006, P. 157-160).

Annotating the observed dynamism in developing economies, contrasting the dramatic changes in some against the dire poverty in others, recognizing the diversity of country experiences ranging from astonishing successes to devastating failures and building on the framework of Maddison (1988), a recent study has classified the sources of growth into three broader categories: *proximate (measurable), intermediate (policy-related) and ultimate (non-measurable) sources.* According to this study, the *proximate sources* of growth include saving and capital accumulation, increased scale of production, efforts, efficiency, accumulation of human capital, natural resources, changes in technology and the organization of production; *intermediate factors* are related to trends in domestic/global demand and a variety of policies while *ultimate sources* comprise geographic and climatic factors, demographic and epidemiological trends, political centralization, history of state formation, the dynamics of class relationships/political conflicts, institutions such as property rights, financial intermediaries, rule of law & order, international order, trade regime, technological gap and absorptive capacity (Szirmai, 2008, P. 5, 13-17). In both of the above analytical theoretical and empirical approaches, the growth spurring roles of investment and trade are emphasised. Hence, differences in investment and trade performances could be among the possible explanations for

the observed growth disparities across countries of the world. Defined as the sum of exports and imports or either of the components, it is said that the growth of trade volume is closely related to the growth of output (Jones, 2002, P. 15). Referring to one of the implications of the Solow model, Jones (2002) elaborates also that countries with high savings/investment rates end to be richer, ceteris paribus; while those with more capital per worker have high output per worker (P. 32).

After discussing the main implications of various growth theories with a particular focus on the roles played by investment and trade, Mekonnen (2011b) asserts,

> *"we learn the economic significance of: (i) investment as a way of capital accumulation and building productive capacity; (ii) trade as a conduit for knowledge-technology transference and a vent of surplus products enabling the exploitation of economies of scale; and, (iii) market mechanisms as the main governing forces imposing disciplines on the efficiency of institutions, all favouring growth. Conversely, the investment and trade performances are also highly tangled to and influenced by economic growth"* (forthcoming).

However, the effectiveness of further investment and trade liberalization efforts in Africa is still debating. There are researchers who argue that investment in Africa is too high; its growth effect in the region is insignificant; and conclude as there is no supportive evidence that private as well as public capitals are productive in Africa (Devarajan, Swaroop and Zou, 1996, P. 338-339, Dollar and Easterly, 1999, P. 552, Devarajan, Easterly and Pack, 2001, P. 81). Based on his cross-country regressions, using data from 87 countries over three different 10-year periods (1965-1974, 1985-1984 & 1985-1994), Barro (2003) has also reported that the positive growth effects of the rate of investment and trade openness become weak when other variables are controlled (P. 231, 235, 259, 273). Others also explain that the existing evidence, obtained from different parts of the world, on the impact of trade openness to economic growth could not lead into a single generalization. For instance, Szirmai (2008) explains the striking contrast between the effects of openness to trade in the South-East Asian (SEA) and African economies. According to him, the most successful South-East Asian economies are characterized as open to the world and

engaged in international trade while trade liberalization in Africa initially led to further economic decline, deindustrialization and stagnation as the non-competitive enterprises were exposed to international competition (P. 25-26). Similar explanations have also been documented in Caves *et al* (1999, P. 132-133).

In sum, from the above brief review, we grasp that the existing pool of evidence on the growth effects of investment and trade, as well as the reciprocal effects, is hardly sufficient, rendering their connections to remain inconclusive. The insufficiency of such studies is chronic when it comes to the Ethiopian economy. To the best of my knowledge, the investment-trade-growth link in the Ethiopian economy in particular is not well studied. However, being translated into a series of plans of export-led transformation towards industrialization with adequate effort to improve agricultural productivity up to its potential, the recent Ethiopian economic policies and strategies emphasise the roles of investment promotion and trade expansion to achieve rapid and sustained economic growth with declining income inequality. Hence, with the intention of understanding the interaction between these economic forces on the face of the emphasis of the national economic policy on their promotion, investigating the investment-trade-growth nexus in the Ethiopian context becomes the objective of this research. Specifically, the study tries to examine the existence of three feedback links: *investment vs. trade, investment vs. growth, and trade vs. growth*. Then, what follows is the identification of the pattern of impact flows amongst these three economic forces in the Ethiopian Economy.

Intended to serve as a medium of transmitting the learning outcomes and main findings of the study on the tri-partite links between investment, trade and economic growth in Ethiopia and invoke other rounds of research, this paper is organized as follows. The next section assesses the existing literature on growth and its main determinants, with special emphasis on the investment-trade-growth links. The third section is a glimpse at the Ethiopian socio-economic situation. The fourth section presents econometric tests and estimation results while the fifth section concludes the paper.

2. Determinants of Growth and Its link with Investment and Trade

2.1. Economic Growth and its Macro-determinants

The world has experienced a wide variation in growth performance and welfare of nations, spatially as well as temporally. Although economists in the field share the facts of variation in per capita income, growth rates, the contributions/influences of factors such as technological progress, increased factor inputs, and the widening gap between the per capita income and living standards across countries, there are some debating issues in explaining the cross country growth deviations. Growth is a complex issue in that many factors interact towards a certain level or rate of growth. Though growth models parsimoniously focus on some but main determinants of growth, for simplicity, finding factors that affect growth performance of nations is not as such simple. There could be a long list of determinants of growth with interwoven interaction among themselves. For instance, Sala-i-Martin (1997) has surveyed a number of production function studies and found that different authors have included at least 62 different variables to explain growth (in Thirlwall, 2003, P. 172). However, Maddison (1988) has classified factors that cause growth differences between countries of the world as *'ultimate'* and *'proximate'* factors. According to him, the domain of ultimate factors include the characteristics of institutions, degrees of social conflict, international orders, ideology and economic policies while 'proximate' (measurable) causes consist of natural resources, raw labour, human capital, physical capital, demographic changes, technological progress and diffusion, international trade and changes in economic structure (in Mekonnen, 1999, P. 3). Maddison himself (1997) has reclassified these factors into four main building blocks. Appreciating world growth as "Since 1820, world per capita income has risen eight-fold", he says

> *There have been four main causal influences which go a long way to explain why such a large increase has been feasible. These are: (a) technological progress; (b) accumulation of physical capital in which technical progress usually needs to be embodied; (c) improvement in human skills, education, and organizing ability; and (d) closer integration of individual national economies through trade in goods and services, investment, intellectual and entrepreneurial interaction. In the literature on economic growth, there are also three other elements considered to*

> *have had an important causal role. These are economies of scale, structural change, and the relative scarcity or abundance of natural resources. All of these causal influences have been interactive so it is not easy to separate the specific role of each* (P.1).

Alternatively, if we mesh the macro-determinants of growth considered by Thirlwall (2003, P. 177-183) and Barro (1991, P. 407-439, 2003, P. 273), the list includes the initial level of per capita income, saving and investment ratios, fertility or population growth, variables that affect the productivity of labour (such as education, health, embodied technological spill over, FDI and others), R & D, trade, political stability (as measured by proxies like political assassinations, revolutions, coups and others), government expenditure, economic system (socialism, mixed economy or free market systems), market (price) distortions, inflation, fiscal and monetary variables and other factors. Here, it is important to note that there are widely overlapping similarities in that trade and investment are included in both of the two alternative categorical lists.

Most empirical studies base their analyses on variables in the above domain although it is possible to cite a number of more determinants of growth. Thus, notwithstanding the possibility of including other more factors in describing growth, it is unlikely to be exhaustive in incorporating all the determinants in theoretical as well as empirical models. Indeed, all determinants of growth have their own contributions to or influences on growth. Nonetheless, the respective influence of factors would vary one from the other or some may work through others. Thus, it might be advisable to focus on certain macro-determinants. It seems partly due to this idea that most empirical studies include only a few determinants and found that income growth is positively related to initial human capital (robustly), investment ratio (robustly), political stability, and negatively related to initial level of per capita GDP (robustly), government share of consumption, and market distortions while it is insignificantly related to the share of public investment (Barro, 1991, P. 407-437, 2003, P. 231-274, Mankiw *et al*, 1992, P. 425-433 & Thirlwall, 2003, P. 177-181).

Hence, following the emphasis of the existing literature on investment as the main path of expanding a productive capacity and openness to trade as a means of technology transference from advanced to less advanced countries and a vent for

surplus products, we delimit our investigation to focus on the interactive links between investment, trade and growth with the expectation of self-reinforcing synergies amongst themselves. As indicated on the summary table of Thirlwall (2003), in the studies of Levine and Renelt (1992) and Levine and Zervos (1993) trade has shown fragile behaviour while it is significantly included in Knight's *et al* (1993) growth regressions. Refereeing to the above studies, Thirlwall says "Interestingly, the variables of significance turnout to be those which have traditionally been at the heart of the main stream growth and development theory, particularly the importance of investment and capital accumulation." (P. 181). However, the question why the role of trade shows fragility remains unaddressed with a normative justification as it might have been working through investment. Thus, the investment-trade-growth link remains elusive. The plausible feedback between trade and investment does not get due attention. Thus, this study attempts to contribute to the existing debate focusing on the investment-trade-growth link using a time-series case study on a less investigated area: *the Ethiopian economy*.

2.2. Investment-Trade-Growth Connections

In the investment-trade-growth relation, plausibly, there could be bi-directional channels through which one causes the other. It would not be unreasonable if we hypothesise that *international trade would lead to greater investment*, *the latter would foster the former and thereby both engender growth.* International trade leads to greater investment by allowing import of investment goods particularly if the country is developing. Imports could increase owing to two reasons. Firstly, the demand from exporting firms would be high. The second is the effect of foreign exchange earnings from exports. Particularly, if the need for investment is emanating from the exporting sector, the process will follow a self-generating circular causation. The exporting sector could import capital goods that are likely to embody state-of-the-art technologies and export more. In such a manner, the process continues without limit. If the economy is outward oriented, domestic firms are encouraged to produce for international market. This lifts the demand constraint that would have been in effect had the economy been inward looking. Hence, investment and production would not be demand constrained. The learning effects (imitating foreign practices) could also motivate to start a new venture or expand the existing one. As long as trade involves imports and business trips, the acquisition

of new ideas and technologies is inevitable. On top of that, if there is a conscious action to bolster imitation, similar to the *reverse engineering and technology licensing schemes* of some SEA countries, international trade liberalization opens the door to new technologies and ideas wider.

Looking at the reverse causality also enables to understand some of the mechanisms through which investment would foster trade. As investment increases, the volume and quality of products would be improved providing competitive advantage to the producing firm and positive externalities to the economy. If the economy is outward oriented, the hypothesis would be more realistic as more of the investment is supposed to be in the exporting sectors which are not constrained by demand limits. This, in its own, enables to improve foreign exchange earnings relaxing the restraint of importing more. In sum, investment fosters both exports and imports or total international trade. The other channel is that investment increases domestic demand which is one of the stimuli to more domestic investment, and attraction for FDI and imports. In this sense, domestic investment increases exports production, attracts imports and FDI. If this argument is persuasive, it could be sensible to prescribe for developing countries to begin with the promotion of domestic investment targeting at export expansion, FDI attraction and then faster growth.

In the growth literature, the attributes of investment attains greater attention. In emphasizing its importance in the process of growth, Bellemore (1964) explains the role of investment as a vital one. The economic essence of investment is attached to capital formation. According to him, the greater the production and employment of capital goods, the greater the capacity to produce goods and services. He says also, the process is self-generating. A larger stock of capital goods will allow greater production, and greater production will generate potentially larger surplus to be saved in capital goods and so on. This is the manner in which the productivity of workers and the level of living could be improved (P. 1). After his extensive analysis, Arthur Lewis (1965) also says "…investment is necessary for economic growth. From this it follows, in a passive sense, that saving is necessary to growth, because investment has to be matched by saving." (P. 213-214). Besides, in their applied research on Namibian economy, Shiimi and Kadhikwa (1999) state that the effects of investment on economic growth are two-folds. Firstly, investment generates part of aggregate demand in the economy stimulating production of investment goods

which in turn leads to high economic growth and development. Secondly, capital formation improves productive capacity enabling an economy to produce more output. Investment in new plant and machinery raises productivity growth by introducing new technology which also could lead to faster economic growth (P. 4).

In general, albeit in varying approaches and degrees of emphasis, all growth models extending from the classical to the neoclassical and endogenous growth thoughts give crucial role to saving and investment in determining, at least, the level of per capita income and standard of living (neoclassical), or the rate of growth of output and living standards (Barro, 1991, P. 429, Plosser, 1992, P. 67, Jones, 2002, P. 32, Thirlwall, 2003, P. 143, Sorensen and Whitta-Jacobsen, 2005, P. 77, Romer, 2006, P. 18-19). That seems why different intellectuals underscore the requisite of investment to growth and development.

Trade liberalization is the other policy prescription for faster growth. It is one of the main explanations given to the miraculous growth of the South East Asian countries and their descendants like China, Vietnam and the Philippines (World Bank, 2006, P. 311, UNCTAD, 2008, P. 4). Based on its study on the trade and growth performances of world countries in the period 1990-2004, the World Bank concludes "In an integrated world, trade spurs growth and growth spurs trade" (2006, P. 311).

From the empirical perspective, lots of works have also been done on the trade-growth link. Surveying many seminal works and using his own empirical analysis, Edwards (1998) has provided evidence as to how openness affects growth. According to him, Romer (1986) and Lucas (1988) have offered persuasive support for the properties that openness affects growth positively, focusing on externality effects as the core of their arguments. In addition, Grossman & Helpman (1991), Romer (1992) and Barro & Sala-i-Martine (1995) have argued that countries that are more open to the rest of the world have a greater ability to absorb technological advances generated in leading nations (P. 1). Based on the coefficient of openness in growth equations obtained from OLS and IV estimations, data from 93 countries, Edwards also concludes that more open countries have indeed experienced faster productivity growth although causality issues are left open (1998, P. 396). Hence, all these ideas share the notion that regards trade as an engine of growth. That seems why eliminating artificial trade barriers, i.e., tariffs, quotas, subsidies, voluntary

export restraints, discriminatory government procurements and local content distortions are at the heart of trade liberalization policy.

The trade-growth transmission channels can be broadly classified into four: the channels of investment, productivity, market, and increasing government commitment/ policies towards spurring growth (Wacziarg, 2001, P. 395-398, Yanikkaya, 2003, P. 73, Anderson and Babula, 2008, P. 9). Similar explanations have also been offered by others, as well. Thirlwall (2003) emphasizes as there are several mechanisms through which trade liberalization may influence the long-run growth rate of an economy. According to him, more trade encourages investment which confers externalities on an economy. If the investment goods come from abroad, greater trade means large volume of output and greater scope of specialization, leading to learning by doing. Trade leads to technology transfer and the prospect of faster total productivity growth (P. 639). Sachs & Warner (1995) also stresses that trade liberalization not only establish powerful linkage between the economy and the world system, but also effectively forces governments to take actions on the other parts of the reform program under the pressure of international competition (P. 2). All the above referred studies focus mainly on a few important mechanisms through which trade may affect growth. These include the channels of investment, new ideas and technology transfer, access to wider market and the discipline that trade imposes on governments, all favouring growth.

In spite of numerous studies explaining the separate episodes and determinants of growth, trade and investment in various spatial and temporal horizons, the evidence on the investment-trade-growth connexions in developing countries is still insufficient and inconclusive. The role of trade liberalization in the process of economic growth is still ambiguous. Some found a lagging positive association (Greenaway *et al*, 1998, P. 1558) while others found it fragile, with a hypothetical justification as it could be working through investment as elaborated in Thirlwall (2003, P. 180-181). Furthermore, the plausible bi-directional link between trade and investment does not get due attention, being in need of further studies. Hence, investigating the investment-trade-growth nexus in the Ethiopian context becomes the objective of this research.

3. A Glimpse of the Ethiopian Socio-Economic Situation

Ethiopia, as one of the least developed countries, has been backward in socio-economic development. Agriculture has been the main source of income and stay of the population. Its overall situation had been deteriorated by prolonged internal & external wars, wrong policies and recurrent drought coupled with ever-rising population resulting into economic stagnation, image deterioration and unattractiveness to investment expansion.

Nonetheless, recent efforts based on pro-poor development policies focusing at economic recovery has started to show promising achievements in socio-economic performances in general attributed to the special emphasis given to the enhanced move to implement *Agricultural Development-Led Industrialization (ADLI)* strategy and deepening policy reforms. Particularly, performances in the recent half a decade years are encouraging. Table 1 shows the recent situation of the country compared to that in the last two decades. As of 2006, the Ethiopian population had been estimated about 72.2 million. In 2000-2006, on average, the Ethiopian urban population is estimated to be only 16 percent while it is estimated to be 36% and 30% for Sub-Sahara Africa and low income countries, respectively. From the whole Ethiopian population, the agricultural employment accounts around 80% while industry & construction hold 8%, and the rest 12 % are employed in government and service sectors (see Figure 1).

The Ethiopian people are living in an extremely low standard. In 2006, the Gross National Income (GNI) per capita of Ethiopia, as measured with atlas method, was estimated to be 180 USD while the respective figures for sub-Saharan Africa (SSA) and low-income countries were estimated to be USD 842 and 650, respectively. Ethiopian GDP had shown a decline from 9.8 billion USD in 1986 to 8.5 billion USD in 1996 while it revived to 11.4 billion USD in 2005 and 13.3 billion USD in 2006. The percentage of people living below the national poverty line (a dollar a day) was estimated to be 44% for the period 2000-2006, on average, while it was estimated to be 38.7% in 2006 fiscal year alone. In the period 2002-2006, the rate of adult literacy in Ethiopia was 36% while the averages of Sub-Saharan and low-income countries were 51% and 61%, respectively. According to CIA (2008), rate of adult literacy has reached 42.7% in 2007. In gross primary enrolment, Ethiopia's achievement was 100%, which is inspiring, while that of the Sub-Saharan and the low-income averages were 92% and 102%, respectively.

Table 1: Some Indicators of the Overall Ethiopian Socio-Economic Situation

Main Indicators			Ethiopia	SSA	Low Income	1986	1986 - 1996	1996	996 - 2006	2005	2006
Population (mill, 2006)			72.7	770	2,403	-	-	-	-	-	-
Urban Population (%, 2000-06)			16	36	30	-	-	-	-	-	-
Literacy (% of population aged 15+, 2000-2006)			36	59	61	-	-	-	-	-	-
Gross primary enrolment[3] (%, 2000-06)			100	92	102	-	-	-	-	-	-
GNI Per Capita (US$, 2006)			180	842	650	-	-	-	-	-	-
GDP (USD, billions)			-	-	-	9.8	-	8.5	-	11.4	13.3
Poverty[4] (%, 2000-06*)			44*	-	-	-	-	-	-	-	38.7
Performance of the Ethiopian Economy	Gross Domestic savings[5]/GDP (%)					11.6	-	9.6	-	-1.6	-6.1
	Gross National savings[6]/GDP (%)					14.3	-	17.4	-	13.7	9.4
	Structure of the Economy (% of GDP)										
		1	Agriculture			56.3	-	56.7	-	46.6	47.3
		2	Industry			11.7	-	10.5	-	13.8	13.5
			Manufacturing			*4.6*	-	*5.1*	-	*5.4*	*5.3*
		3	Service			32	-	32.8	-	39.6	39.2
	Average Annual Growth Rates	1	GDP (%)			-	1.7	-	4.6	10.2	9.0
		2	GDP Per Capita (%)			-	-0.9	-	2.3	8.2	6.8
	Average Annual Growth										
		1	Agriculture			-	3.0	-	2.8	13.4	11.2
		2	Industry			-	-2.1	-	6.2	8.1	*7.4*
			Manufacturing			-	*-3.5*	-	*4.4*	8.0	*8.1*
		3	Service			-	1.4	-	5.9	8.1	8.5

Source: Compiled from World Bank Data, 2007

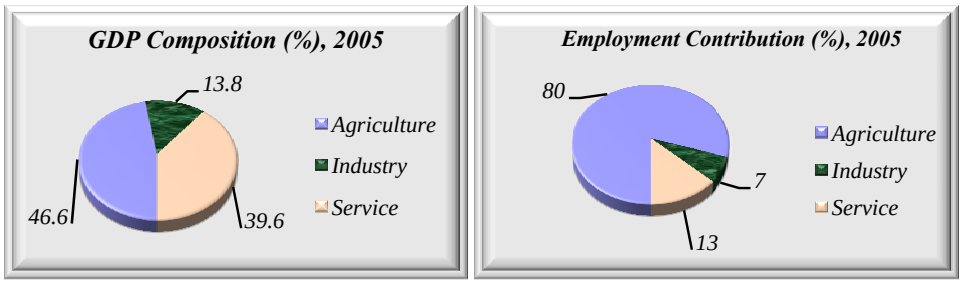
[3] *Gross primary enrolment is measured as the percentage of school age population.*
[4] *Poverty is measured by percentage of population below the national poverty line.*
[5] *Gross domestic savings are calculated as the difference between GDP and total consumption by households and the general government.*
[6] *Gross national savings is gross domestic savings plus net income and net current private transfers from abroad.*

The disappointing economic performance of Ethiopia might have been deep-rooted in the past eras. Let alone centuries, a contrast between the recent two decades, 1986-1996 & 1996-2006, shows that the performance of the economy under the first decade was worse. Indeed, per capita income was declining at an annual average of 0.9%. Whereas, the economy performed better in the second in that both GDP and per capita GDP grew at positive rates with slight tendencies of economic transformation from the agricultural ubiquity (56.7% - 47.3%) towards service (32.8% - 39.2%) and a little to the industrial (10.5%-13.5%) wings. However, the transformation has been lethargic and unhealthy in that the economy is tending to transform to the service sector that most of its activities are subject to diminishing returns in productivity and could not play a leading role in the development process while the promising industrial sector remains stagnated for long time (Table 1).

The industrial sector has remained at its infant stage in that its contribution to the economy is very minimal. It was accounting for about 12% in 1986. But, after 20 years, its contribution has not increased more than 2 percentage points. The manufacturing sub-sector has also shown a sluggish increase from 4.6% in 1986 to 5.3% in 2006. Thus, the sluggish drag of the economic transformation towards industrialization seems at the root of the economy's stagnation. Annualized average growth rates of the respective sub-sectors explain the bad performance in the first and improvements in the second decades (see Table 1).

However, still the economy is highly agrarian (Figure 1) making it very sensitive and vulnerable to natural shocks particularly rain/drought, in addition to its nature of diminishing productivity and demand inelastic limits.

Figure 1. GDP Composition and Employment Contribution of the Ethiopian Economy, 2005



Source: Table 1 (World Bank, 2007)

Source: Data from World Bank, WDI, 2010

Using another set of data, the economic performance of the country has been evaluated based on the political regimes coinciding with different economic systems, the pre-1974 feudalist, the 1974-1991 socialist and the post-1991 market orientated economic systems. Although it does not cover the whole periods of the three economic systems, Table 2 presents the average achievements of four macroeconomic variables for 1962-2005, on five year basis.

According to Table 2, on average, real GDP had been growing at declining rates for three successive five-year terms. It declined from 4.7% in 1962-66 to 4% in 1967-71 and to 1.3% in 1972-76. Following its moderate improvements in the two subsequent five-year periods, it sharply fell to -0.01% in 1987-92, most likely due to the power-shifting war. Following the improved average growth performance (5.7%) of the 1993-2000, the economy had enjoyed the best average rate of growth in the recent period, 2001-2005 (6.6%). Here, it is noteworthy to remember that the *coup d'état* of the feudal and the overthrow of the socialist systems were carried out in 1974 and 1991, respectively. Hence, the growth performances, in the time ranges in which these years of critical political turmoil lie, had been the worst of all signifying the worth of political stability to prosperity.

Inflation had two digit figures in the periods that include years of *power-shift.* According to Gylfason (1999), high inflation could be a symptom and/or a result of economic mismanagement, imperfect institutions such as fragile banks, financial market and other factors (P. 1039). The performance of exports relative to import was high and increasing during the feudal system and had fallen steadily reaching

below half of imports in the last period, 2001-2005. For the whole pre-1992 period, openness of the country measured by the volume of exports plus imports as a percentage of GDP had been fluctuating around an average of 24.7% with its lowest of 20.2% in 1987-92 and its highest 29.1% in 1977-81. During the period 1962-1992, it has never been above 30%. Nonetheless, in the period 1992-2000, the measure of openness rose to 37.8% followed by further rise to 42.6% in the period 2001-2005. Hence, these facts clearly show the relatively closed nature of the economy and the suppression of trade in the pre-1992 while relative improvements in trade openness and liberalization are exhibited in the post-1992 period.

Table 2: Major Macro Economic Indicators of Ethiopia, 1962-2000

Indicators	Performance Periods							
	1962- 1966	1967- 1971	1972- 1976	1977- 1981	1982- 1986	1987- 1992	1993- 2000	2001- 2005
Real GDP Growth Rate (%)	4.7	4.0	1.3	2.3	3.7	-0.01	5.7	6.6
Total Investment as % of GDP	13.5	12.6	9.7	11.0	14.3	13.4	15.9	23.0
Private investment as % of GDP	3.9	4.1	3.1	2.7	3.7	4.0	4.8	5.5
Saving as % of GDP	11.4	11.0	9.0	4.7	6.5	7.1	5.3	19.2
Inflation (%)	-	1.7	11.4	10.7	3.4	11.8	3.8	3.44
Exports & Import as % of GDP	24.1	22.1	26.5	29.1	26.0	20.2	37.8	42.6
Export as % of Imports	83.6	86.6	95.8	53.6	53.7	52.3	56.4	47.2

Source: NBE and MEDaC (2002); Private investment as % of GDP is computed from PWT, Version 6.2 (2006), and all except the Private investment data for 2001-2005 are taken from the World Bank, WDI Online Database, 2010.

Investment has been very low and declining over time in spite of the recent revival. On average, total investment as a percentage of GDP revealed the same fall and rise trends. It declined from 13.5% (1962-66) to 9.7% (1972-76) while it appeared at its highest (23%) in 2001-2005. Private investment is extremely thin in Ethiopia. It has never constituted more than 33 percent of total investment. The slight revival of the

average rate of private investment (saving) from 3.7% (6.5%) in 1982-1986 to 4% (7.1%) while total investment declined by 0.9% in the same period could be reflecting the effects of policy shift from the socialistic to the mixed economic system enacted within the last years of the 1987-92 period. From these facts, one can understand that the middle socialist system had experienced the worst of the three while the last market-oriented system had achieved relatively finest achievements in real GDP growth and rates of investment though performances in the recent years are not considered. Hence, political systems, the accompanying policies and the interwoven adverse effects of political and macroeconomic instabilities (exacerbated by the devastating prolonged civil war) seem among the causes for the deterioration of the economy in general, the private sector in particular and inter-temporal performance differences. However, this study is not intended to investigate the impacts of political systems & policies enacted. Rather, it attempts to address a question: *how investment, trade and growth interact in the economy?*

4. Empirical Investigation on the Investment-Trade-Growth Links

This section attempts to provide some evidence on the dynamic interdependence between private investment, trade openness and economic growth, expecting three feedback links: *investment vs. trade openness;* i*nvestment vs. economic growth; and, trade openness vs. economic growth*.

4.1. Data and Related Tests

The data set is annual time series covering the past five decades (1950-2003) with a total of 54 observations, involving three variables: *trade to GDP (openness) ratio, private investment and real per capita GDP.* The GDP data series is given in 2000 constant US dollar price adjusted for Terms of Trade (TOT) changes while private investment and trade openness are given as percentage shares of GDP. The data are taken from Heston, Summers and Aten's Penn World Tables, Version 6.2 (2006). Since the original investment data is given as a percentage share of GDP, multiplying the share by GDP and then dividing by 100 generates the annual real dollar value of investment, adjusted for TOT. The descriptive statistics of the levels data have been displayed on Appendix Table 1. As the variables defined above are typical time series, they may involve non-stationary or unit root process. Working with non-

stationary time series in that the mean, variance and covariance are not time-invariant could lead a researcher to end-up with a spurious regression superficially looking good but seldom reflecting the true relationship between the variables of interest. Hence, a Unit Root test of stationarity has been conducted using Augmented Dickey Fuller (ADF) test developed by Dickey and Fuller (1979).

i. Unit Root Test of Stationarity

The formal Unit Root test of stationarity has been conducted on the present and 4 lag values in that the ADF statistics are used at 5% and 1% significance levels on the log levels & their first-differences. In addition to its ability to accommodate higher-order autoregressive error processes or some forms of serial correlation, the ADF test is taken for its superior property of taking short-run dynamics into account to whiten the residuals, compared to the Dickey–Fuller (DF) test (Greene, 2003, P. 643). Moreover, indicative of the powerful finite sample features of the DF tests over the Phillips-Perron (1988) tests, Greene (2003) explains "The Dickey–Fuller procedures have stood the test of time as robust tools that appear to give good results over a wide range of applications. The Phillips-Perron (1988) tests are very general, but appear to have less than optimal small sample properties" (P. 645). Hence, for its advantage in accommodating higher order serial correlations over the DF and superior finite sample properties over the Phillips-Perron tests, the ADF unit root test of stationarity has been employed based on the following autoregressive specification that contains lagged differences with the optional inclusion of a constant, or a constant & trend:

$$\Delta y_t = \alpha + \mu t + (\beta - 1) y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t$$

In this test, the null hypothesis is that *'the underlying time series is non-stationary ($\beta - 1 = 0$ implying a unit root)'* against the alternative hypothesis of *'the time-series is stationary ($\beta - 1 < 0$)'*. Hence, a rejection of the null hypothesis implies stationarity of the series under consideration. As indicated in Table 3, the ADF test on the levels data series does not reject the non-stationarity hypothesis at both 1% and 5% significance levels. The stationarity test results show that the levels series of these variables are found non-stationary while their first-differences are stationary dominantly up to the fourth lags at 5% and 1% significance levels. The Unit Root test

of stationarity is not altered by the alternative inclusion of a constant or a constant & trend. Hence, we characterize the data series as integrated of order 1, I(1).

Table 3: Unit Root Test Results with *Constant*, and *Constant and Trend*

Ho: *Non-stationary*

Variables	t - ADF With Constant					t - ADF With Constant and Trend				
	Lags					Lags				
	0	1	2	3	4	0	1	2	3	4
inv	-1.023	-0.880	-0.861	-0.964	-1.049	-3.658*	-3.186	-3.127	-2.995	-2.840
open	-0.980	-0.890	-1.131	-0.843	-0.834	-1.898	-1.838	-2.262	-1.853	-1.899
rgdppc	-1.565	-1.001	-1.091	-1.087	-1.364	-2.484	-1.714	-1.859	-1.912	-2.419
Δinv	-8.517**	-5.852**	-5.088**	-4.683**	-4.147**	-8.432**	-5.798**	-5.036**	-4.643**	-4.071*
Δopen	-7.238**	-4.329**	-4.468**	-3.801**	-3.356**	-7.192**	-4.309**	-4.436**	-3.756*	-3.502*
Δrgdppc	-9.785**	-5.149**	-4.003**	-2.880**	-2.510**	-9.673**	-5.058**	-3.907*	-2.803	-2.464
Critical Values	5 %	(-2.92)		1 %	(-3.57)	5 %	(-3.50)		1 %	(-4.16)

Note: *Lower case letters indicate the natural logarithmic levels of the data.*

Despite the non-stationarity of each data series, there could be a linear combination between the variables that could produce stationary process. Hence, whether contegrating relationships exist should be checked before passing to the next specification steps.

ii. Cointegration Test

With the help of Johansen's (1988) Trace test for cointegration of I(1) with the inclusion of up to 4th lags, we found that there is no cointegrating relationships between the variables considered.

Table 4: Johansen's Co-integration of I(1) Test results (with 4 lags)

H0: Co-integrating rank, r ≤ p, (where p = 0, 1, 2)

Null Hypothesis	Trace Statistic	[Prob]	Implications
r = 0	21.793	[0.320]	1. Do not reject the null hypothesis (r = 0)
r ≤ 1	10.594	[0.242]	2. VAR in differences is stable
r ≤ 2	2.656	[0.103]	3. No long-run relationships

The use of a year dummy variable as an unrestricted regressor (YD = 1 for years 1955 – 1960, 1984, 1987, 1988 and 1991 and zero otherwise), owing to some outlying observations, does not alter the outcome of the test results.

4.2. Empirical Model Specification and Estimation Methodology

Appropriate to the properties of the data set and the research objective, Sims' (1980) Vector Autoregression (VAR) methodology has been proposed as a solution to the estimation problem. The stationarity test results reported in Table 3 show that the levels series of the variables are non-stationary while their first-differences are stationary dominantly up to the 4th lag. In addition, Johansen's (1988) Trace test indicates the non-existence of cointegrating relationships amongst the variables (r = 0) implying VAR in differences is stable; no long-run relations between the variables while it could be informative about short-run relationships. Hence, we specify a VAR(*p*) model with the first differences of the variables as:

$$\Delta \boldsymbol{y_t} = \boldsymbol{\alpha} + \sum_{i=1}^{p} \boldsymbol{\beta_i} \Delta \boldsymbol{y_{t-i}} + \boldsymbol{\varepsilon_t} \qquad \textbf{(1)}$$

where Δ is the change in our vector of endogenous variables $\boldsymbol{y_t}$ *(logINV, logOPEN & logRGDPPC) at time t; α is a vector of constant terms;* $\boldsymbol{\beta}$ *is a matrix of parameters and* $\boldsymbol{y_{t-i}}$ *is a vector of pre-determined variables, at lag i; and* $\boldsymbol{\varepsilon}$ *is a vector of white noise disturbances.*

The next step is to determine the optimal lag length (*p*). The test results, displayed in Table 5, show that lags 2-4 are not significantly different from zero in both tests for each lags separately and for all 2-4 lags jointly while only the first lag appears significant.

Table 5. Optimal Lag Length Determination

H0: the lag coefficient is zero

Tests on the significance of each lag			Joint Tests on the significance of lags up to 4		
Lag	**F-Test Value [Prob]**	**Decision**	**Lag**	**F-Test Value [Prob]**	**Decision**
Lag 4	F(9,82) = 0.431 [0.914]	Do no reject Ho	Lag 4 – 4	F(9, 82) = 0.431 [0.914]	Do no reject Ho
Lag 3	F(9,82) = 1.419 [0.193]	Do no reject Ho	Lag 3 - 4	F(18, 96) = 0.833 [0.658]	Do no reject Ho
Lag 2	F(9,82) = 0.417 [0.922]	Do no reject Ho	Lag 2 - 4	F(27, 99) = 0.669 [0.884]	Do no reject Ho
Lag 1	F(9,82) = 3.289 [0.002]***	Reject Ho	Lag 1 - 4	F(36, 101) = 1.422 [0.088]*	Reject Ho

Based on these information, a *vector autoregressive of order 1, VAR(1)* model is specified as*:*

$$\Delta y_t = \alpha + \beta \Delta y_{t-1} + \varepsilon_t \quad \textbf{(2)}$$

That could be expanded as a 3-dimensional vector of equations:

$$\begin{bmatrix} \Delta inv_t \\ \Delta open_t \\ \Delta rgdppc_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} + \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix} \begin{bmatrix} \Delta inv_{t-1} \\ \Delta open_{t-1} \\ \Delta rgdppc_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad \textbf{(3)}$$

The coefficients from the estimation of this specification will be interpreted as follows: *the cross-diagonal coefficients are short-run spillover effects of one over the other. The diagonal coefficients represent the effect of the past on its own current.* The variables are the first-differences of the logs of private investment, trade openness (trade to GDP ratio) and real per capita GDP. The descriptive statistics of the data of the three variables are presented in Table 6.

Table 6. Descriptive statistics of the first differences (growths) of the data

	Statistical Summary				Correlation Matrix		
Variables	**Mean**	**St. Dev.**	**Min**	**Max**	**Δinv**	**Δopen**	**Δrgdppc**
Δinv	0.086	0.220	-0.45	0.63	1.000		
Δopen	0.035	0.137	-0.29	0.51	0.370	1.000	
					(0.006)		
Δrgdppc	0.013	0.067	-0.23	0.22	0.009	-0.230	1.000
					(0.949)	**(0.097)**	

The figures beneath the correlation coefficients are significance p-values.
Sample period: 1951 – 2003

4.3. Results of VAR(1) Estimation

According to the diagnostic test results, the explanatory powers of the estimated models are modest. The residuals from each of the equations and the system are checked for no-autocorrelation, normality and homoscedasticity properties. As indicated in the lower panel of Table 7, all the tests have not rejected their null hypotheses of *no-autocorrelation, normality and homoscedasticity* for all equations separately and for all vectors of the variables jointly at all conventional significance levels except normality in the investment equation where it is rejected marginally at 10 percent significance level. Hence, the fulfilment of the required properties in all

of the equations and their system jointly are in support of the use of the estimated models for the intended analyses. Furthermore, the non-serial correlation in errors is preserved and the effective number of observations (49) is greater than 30 so that estimates and test results remain valid to rely on, *by the central limit theorem.*

Based on these justifications, our causality estimates between investment, trade openness and economic growth suggest that there is no feedback link between any pair of the variables considered out of the 6 ($n \times n\text{-}1$) expected spillover effects; where n is the number of endogenous variables. Nonetheless, we have observed two uni-directional positive short-run causalities that run from real per capita GDP to trade openness and from trade openness to investment. The uni-directional causality running from real per capita GDP to trade could be indicating the direct positive effects of increased production on either the supply of exports or the demand for imports, or both. The identified positive effect of growing trade openness on investment could also be interpreted as a multifarious impact of trade in that exports relieve the foreign exchange stress which is necessitated to import investment goods and indispensable intermediate inputs. Trade also provides access to large markets so that investment and production could not be demand constrained, opportunities to learn from foreign practices and facilitates the transfer of new ideas such as new ways of doing things, efficient management styles, developing new products, marketing skills, etc.

Besides, two negative own impulse-response transmission mechanisms from lagged investment to current investment, consistent to our single equation estimation results of the full sample period (Mekonnen, 2011, P. 176); and, from lagged per capita GDP to current per capita GDP (perhaps exhibiting short-run cyclicality) have been observed. The alarming evidence is that the one period lag of either of the growth force is not supported to provide information in explaining real per capita GDP growth of the country. Rather, the estimates are signed unexpectedly negative despite insignificant (see Table 7). It is a contradiction to our finding for the SSA economies on average (Mekonnen, 2011a and 2011b, forthcoming). In this sense, Ethiopia, where the mechanisms for the translation of investment into grapes of economic growth seem malfunctioning, may not be an ideal representative of the SSA economies.

Table 7: Results of Parameter Estimation and Diagnostic Tests, VAR(1)

Endogenous variables: Δinv, Δopen, Δrgdppc; Sample: 1955 - 2003; Obs = 49

			Equations in the System of VAR (1)		
			Δinv	**Δopen**	**Δrgdppc**
			Coef. [P-Value]	**Coef. [P-Value]**	**Coef. [P-Value]**
Vector of	Δinv_1		-0.305 [0.035]**	0.118 [0.141]	-0.051 [0.197]
	Δopen_1		0.412 [0.068]*	0.058 [0.644]	-0.062 [0.313]
	Δrgdppc_1		0.499 [0.242]	1.234 [0.000]***	-0.373 [0.003]***
	Constant		0.032 [0.318]	-0.007 [0.689]	0.025 [0.006]***
Diagnostic Tests	R^2(LM)		0.21		
	Equations	*AR1-4 Test F(5,38)*	*0.574 [0.683]*	*0.703 [0.595]*	*1.880 [0.133]*
		ARCH1-3 F(5, 33)	*0.014 [0.998]*	*1.068 [0.374]*	*0.936 [0.433]*
		Normality Chi^2(2)	*5.124 [0.077]**	*0.202 [0.904]*	*2.372 [0.305]*
		hetro test F(9, 33)	*0.959 [0.490]*	*0.844 [0.582]*	*1.380 [0.237]*
		helto-X test F(17, 25)	*1.151 [0.366]*	*0.649 [0.820]*	*1.678 [0.117]*
	Vector	*AR1-4 Test F(36, 86)*	*0.882 [0.656]*		
		Normality $\chi^2(6)$	*5.856 [0.439]*		
		hetro test F (54, 147)	*0.886 [0.690]*		
		helto-X test F(102, 121)	*1.082 [0.338]*		

Note: 1. *Numbers in parentheses are P-value; 2. In addition to the removal of the first 4 observations, two year dummy variables have been employed to account for outlying observations and correct for normality problems in the distribution of the variables (INV: YD_1 = 1 for years 1955–1960 & 1984; GDP: YD_2 = 1 for years 1984, 1987, 1988 and 1991 & zero otherwise); hence, forecasting is impossible.*

As indicated by the estimated correlation coefficient (-0.23), the association between trade openness and economic growth are also negative. The results on the last column of Table 7 show as there is no significant causal effect from trade openness to economic growth in Ethiopia. This is also a contradiction to our bi-directional positive feedback finding from the 3SLS and SUR analyses for SSA economies, on average (Mekonnen, 2011a and 2011b, forthcoming). All the above analyses have also been supported by the respective impulse-response functions (IRFs) (Appendix Figure 1) and short-run Granger causality test results (Appendix Table 2). The stability and other behaviours of the estimated VAR model have also been illustrated by the companion matrix and the scaled residuals plotted as Appendix Figures 2 and 3.

There could be a number of reasons for the non-recognizable estimates of investment and trade openness in the growth equation of Ethiopia including the low quantity as well as poor quality of investment, exports and imports or the methodological pitfalls, the behaviours of the data set and its inadequate treatment.

Related with the quantity of investment, it could be worth remembering that the share of private investment in GDP has stayed below 6% up to 2003. This small share of private investment in GDP might have made its growth contribution negligible as its weight is less than 0.06. The trade performance has also been suppressed until recently; particularly, the performance of exports relative to imports has been continuously declining. On average, it decline from 86.6% in 1967-1971 to 56.4% in 1993-2000 and then to 47.2% in 2001-2005 (refer Table 2). This relative decline of exports could have resulted in a persistent deficit in the trade balance of the country exacerbating the balance of payments difficulties; i.e., foreign exchange stress obstructing the importing capability and then the efforts of relaxing the supply capacity of the country.

In addition to the quantity considerations, studies also emphasis the underlying conditions and the quality of investment, the type of products traded and the stock of human capital for investment and trade to be effective. For instance, Gylfason (1999) argues that without factors that encourage high-quality investment like stable prices and proper incentives, gigantic investment alone does not guarantee rapid and sustainable growth (P. 1049-1050). This could be one of the reasons for the insignificance of investment in the growth estimations of SSA as discussed in Devarajan, Swaroop and Zou (1996), Dollar and Easterly (1999), Devarajan, Easterly and Pack (2001) where investment is argued to be high but not productive, and that of ours obtained from this study, using VAR estimation.

While trade is regarded as a conduit of technology-knowledge transference from advanced to less advanced countries, as predicted by the endogenous growth models, accessing the available technology-knowledge is argued to be conditional on the absorptive capacity of the lagging economies. The latter is highly dependent on the stock and quality of human capital which is not sufficiently available in the SSA countries like Ethiopia, worsened by endless brain drain. Furthermore, agrarian economies exporting dominantly primary products, for that Ethiopia is a typical

example, may not benefit from their trade engagements. There are studies that argue as specializing on primary exports as unpromising. Justifying with the adverse trends and the high variance of the prices of primary products, Bleaney and Greenaway (2001) conclude "Specialization in primary product exports reduces growth" (P. 491). A synthesis of similar arguments have also been provided in Thirlwall (2006, P. 528-529). However, the results indicating the non-recognizable effects of investment and trade may not be associated with a single cause; rather, many of the above reasons might have contributed to the observed weakness of the econometric estimates.

Related with the data and methodological pitfalls, the employed annual time series data may not be sufficient while VAR estimation is data intensive; differencing might have caused loss of some useful information; and, significant correlation between the growths of investment and trade variables with a coefficient of 0.37 (see Table 6) may also indicate their modest collinearity. In addition, if trade enhances economic growth through its impact on investment, their simultaneous inclusion into growth regressions could lead to the insignificance of both. Hence, their alternative inclusion in the growth estimations could be among the approaches suggested for future research.

On top of the above suspicions, time series studies generally are also observed to produce such weak results. Reppas and Christopoulos (2005) say "…causality tests are in general unsupportive of the export-led growth hypothesis" (P. 930). Substantiating with Ram's (1987) and Greenaway & Sapsford's (1994) weak results, Thirlwall (2006) asserts that the relationship between exports and growth is much weaker when time series studies are conducted for individual countries against the strong positive associations supported by cross-section studies (P. 534). Thus, if not reflecting the true relationships, our VAR estimation results could have appeared weak due to the employed time series data or estimator, requiring further checks with the inclusion of the recent data, alternative consideration of investment and trade variables in VAR estimations and the use of other estimation approaches such as single equation estimations.

5. Conclusion

The investment and trade performance of the Ethiopian economy has been weak until recently. Private investment has also remained thin. It has never constituted more than 33 percent of total investment. Despite its recent revival reaching 42.6 % of GDP, trade (measured by the sum of exports and imports as a percentage of GDP) has been suppressed for the most of the pre-1992 period; the socialist regime being the worst. The investment, trade and growth connections in the Ethiopian economy have not been well researched. With the objective of characterising the patterns of impact flows between investment, trade and growth in Ethiopia, this study becomes a short-run causality analyses on their dynamic links using time series data over the period 1955-2003.

Our causality analyses on the dynamic link amongst investment, trade and economic growth have brought us about to conclude as there is no feedback between any pair of the variables considered out of the three hypothesised dynamic feedback links. Nonetheless, we have observed two uni-directional positive causalities that run from economic growth to enhanced trade openness and from the latter to investment.

The estimated results are sensible in most instances but some are alarming as well as puzzling. There could be a number of reasons for some of their puzzling properties. The crucial point is the unsupported contribution of the lags of both investment and trade towards economic growth which have been revealed by the corresponding insignificant coefficients in the growth equation. In fact, the share of private investment in GDP has never been above 6% up to 2003. This small share of private investment in GDP might have made its growth contribution negligible as its weight is less than 0.06. The trade performance has also been suppressed until recently. Thus, it is not surprising that the investment-trade-economic growth links are weak in a country where the overwhelming economy is dominated by the production of primary products, which has also been devastated by prolonged war, recurrent drought, inappropriate policies low institutional capacities and discipline, low social and infrastructural services, highly dependent on aid and debt and so forth structural problems.

However, the evidence should not be interpreted as investment and trade do not contribute to the growth process of the country. Rather, it could be signalling the low investment and trade performances of the country for long time though the minimum thresholds of the rate of investment and trade openness are unknown for their respective impacts to be recognized. Hence, measures that improve the performance of activities, their linkages and the contribution of trade to investment could help the economy to build its productive capacity. But, it is our conviction that some of the results should be taken cautiously and checked with different data sets and single equation estimations. Since trade is also argued to impact economic growth through investment, their simultaneous inclusion could lead into the insignificance of the two variables. Hence, the alternative inclusion of investment and trade variables in VAR estimations could be among the lines of further research.

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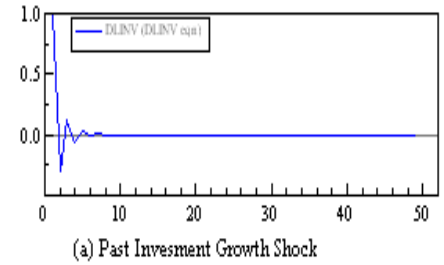
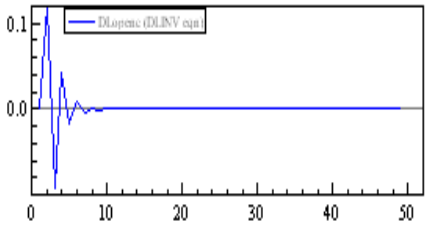
Appendix

Appendix Figure 1. Impulse-Response Shock Transmission Mechanisms:
Amongst the Growths of Domestic Private Investment, Openness to Trade & GDPPC of Ethiopia

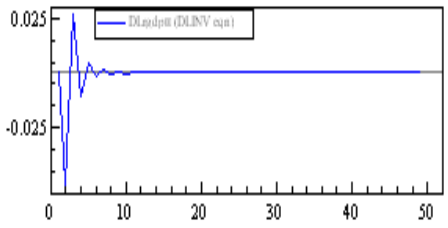
(i) Single IRF of Investment Growth



(a) Past Invesment Growth Shock

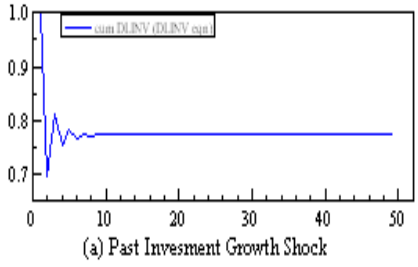


(b) Openness to Trade Growth Shock

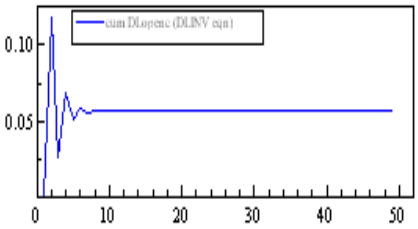


(c) Real GDP Growth Shock

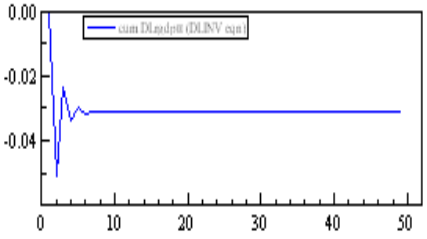
(ii) Accumulated IRF of Investment Growth



(a) Past Invesment Growth Shock

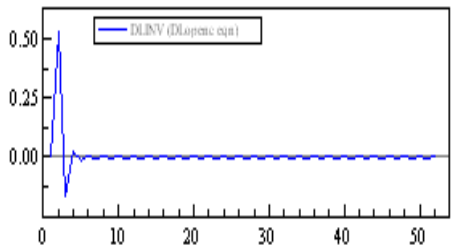


(b) Openness to Trade Growth Shock

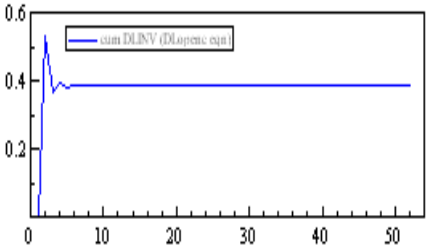


(c) Real GDP Growth Shock

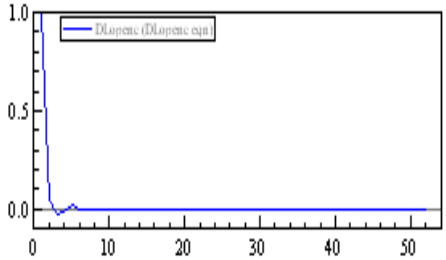
(iii) Single IRF of Openness to Trade Growth **(iv) Accumulated IRF of Openness to Trade Growth**



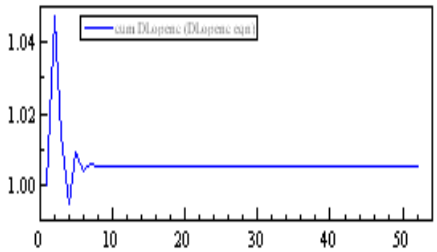
(a) Investment Growth shock



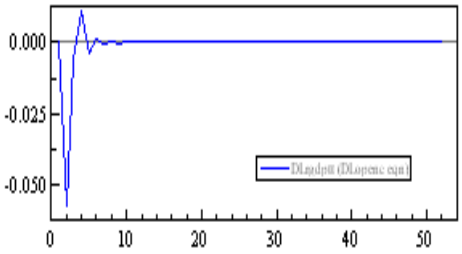
(a) Investment Growth shock



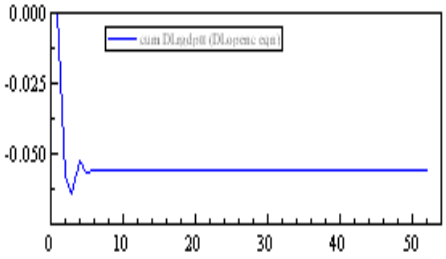
(b) Openness to Trade Growth Shock



(b) Openness to Trade Growth Shock

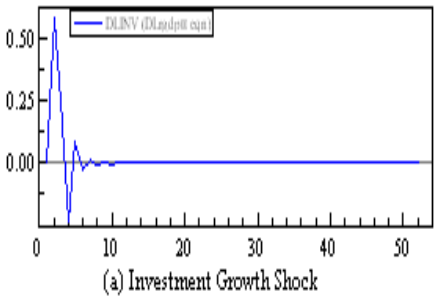


(c) Real GDP Growth Shock

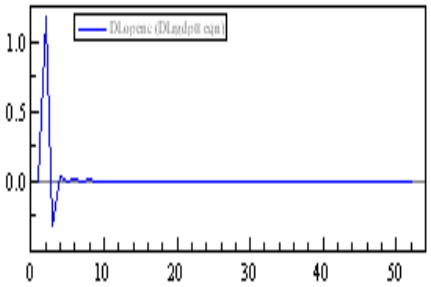


(c) Real GDP Growth Shock

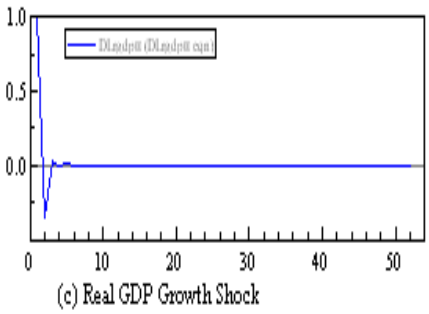
(v) Single IRF of Real GDPPC Growth



(a) Investment Growth Shock

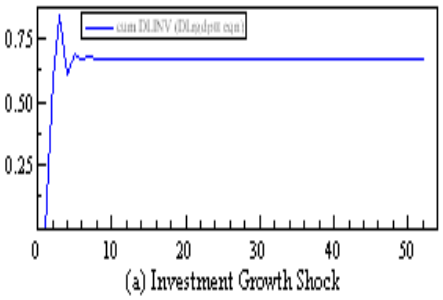


(b) Openness to Trade Growth Shock

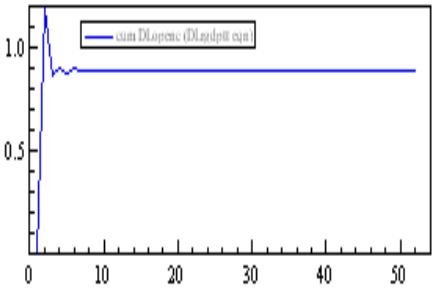


(c) Real GDP Growth Shock

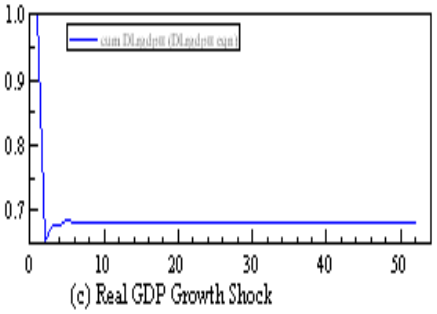
(vi) Accumulated IRF of Real GDPPC Growth



(a) Investment Growth Shock

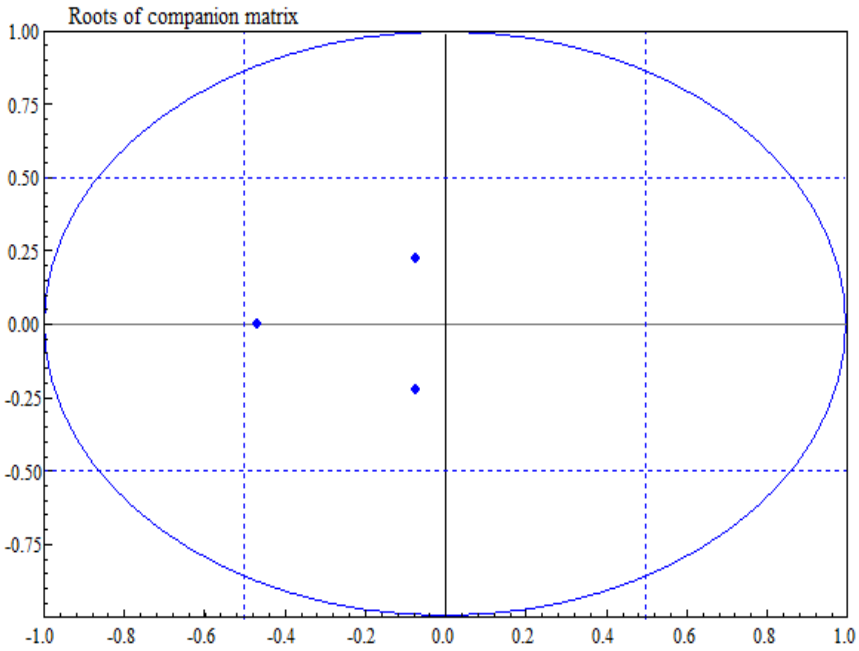


(b) Openness to Trade Growth Shock



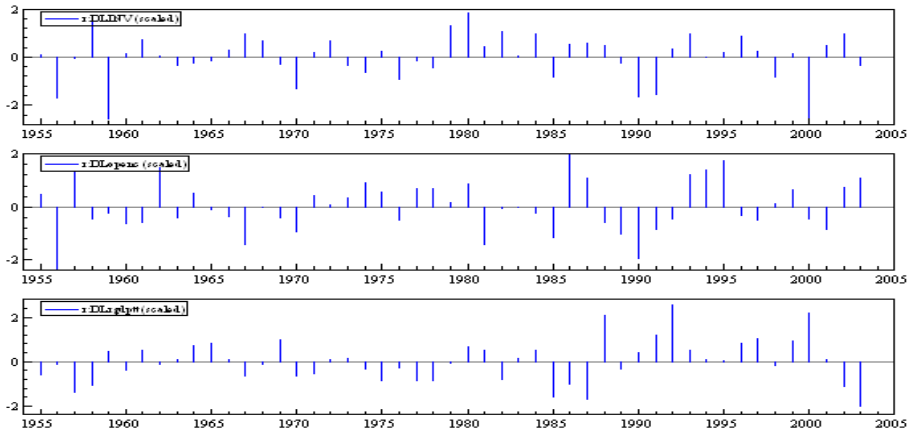
(c) Real GDP Growth Shock

Appendix Figure 2. Stability of the estimated VAR model ***(All the Eigen values or roots of the Companion Matrix are inside the unit circle; hence, the system is stable)***



Appendix Figure 3. Plots of Scaled Residuals (*Residual/equation standard error*) of *Investment, Trade Openness* and *GDPPC Growth* Equations (in order) of the VAR model

(The rule of thumb for dramatic outliers is out of ± 3.5)



Appendix Table 1. Descriptive Statistics of the Levels Data

Variable	Description	Measurement Unit	Obs	Mean	St. Dev.	Min	Max
INV	*Private investment*	2000 US$, in per capita terms	54	11.19	10.29	0.34	34.31
OPEN	*Openness to trade*	percent	54	26.80	10.23	8.74	55.75
RGDPPC	*Real GDP per capita*	2000 US$, adjusted for TOT	54	500.83	90.39	328	732.57

Appendix Table 2. Short-run Granger Causality Test Results

H0: No Granger Causality

Variables		Equations		
		Δinv	**Δopen**	**Δrgdppc**
		χ2[P-value]	***χ2[P value]***	***χ2[P-value]***
Exclusion Restrictions	Δinv_1	5.101 [0.024]**	0.613 [0.433]	1.545 [0.214]
	Δopen_1	6.293 [0.012]**	0.144 [0.705]	1.018 [0.313]
	Δrgdppc_1	2.020 [0.155]	23.991 [0.000]***	9.888 [0.002]***