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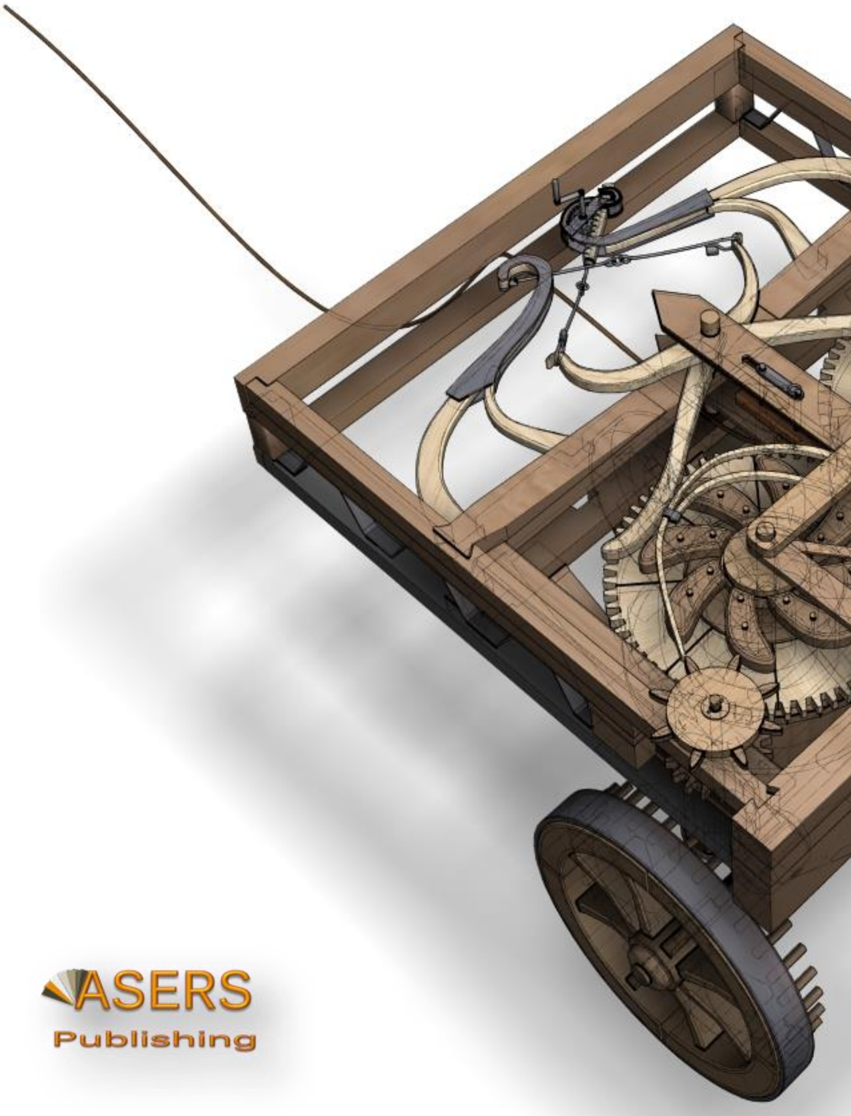

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Theoretical and Practical Research in Economic Fields

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DOES INFLATION INCREASE THE EXPORT? CASE STUDY TURKEY

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Abstract:

In this study the impact of inflation and lower exchange rates on exports is researched and the effects on trade capacity are questioned. Theoretical and practical experiences show that inflation and lower exchange rates can be used as an important instrument for increasing export capacity. However, in Turkey neither higher inflation rates between 1970 and 2000, nor lower inflation rates between 2000 and 2010 made any significant contribution to increasing trade capacity. But, the trade capacity of Turkish producers steadily increased between 1980 and 2010.

The effects of higher inflation on increasing export capacity are still a continuing issue. In this study qualitative and quantitative research methods are used for estimating the impact of inflation on exports? What are the effects of inflation on increasing export capacity? What measures and policies will contribute to increased trade capacity? Also researched, is what the real contribution of the exchange rate regime is to trade capacity.

Devaluation of domestic currency has several effects on the economic parameters; but lower cost production methods, resources advantages, innovation and economic convergences had considerable effects on Turkish trade regime.

Keywords: Export, Turkey, inflation, international trade, trade balance.

JEL Classification: F, F4.

1. Introduction

In international trade some important measures are used to affect trade capacity. One of these tools is the rate of inflation. But there are some other measures and regulations, which support and change the trade capacity. One of the important regulations on Turkish trade was the devaluation of the Turkish Lira, to encourage exports and this measure was used nine times as an instrument for reducing the deficit on foreign trade balance. However, devaluation causes cost inflation as well as an increase in general price levels. This increases the foreign debt amount and may have less effect on increasing export capacity because most of the developing countries are dependent on the agricultural sector, and the demand capacity of agricultural products may not change by reducing prices.

In this study the impact of support measures on Turkish trade is not questioned, but the impact of the inflation rate as a tool for changing the trade capacity is researched. By doing this, the effects of inflation on the current account deficit are also questioned. In addition, political regulations and some other important issues are considered to better estimate the effects of all policies and measures as a tool for increasing export capacity.

In this study qualitative and quantitative research methods are used to estimate the effects of inflation and the exchange rate mechanism on trade capacity. In quantitative research empirical data and theories are used to support the survey in this study. The aim of this research is to estimate the effects of inflation on exports and to determine whether inflation and the exchange rate can be used as a tool for increasing the export capacity in a home country, as well as to determine which instrument and policy is used as a tool for improving trade capacity.

2. General glance at trade in Turkey

Since 1980 the Turkish trade policy has had considerable positive effects on the development of exports. In the 1970s the Turkish trade regime was based on import substitution and concentrated especially on the domestic market. After a decade, in 1980, some economic regulations came into force on 24th January, when liberal economic adoption was realized. After the 1980 economic regulations, the Turkish foreign trade regime was replaced with the export-oriented industrialization model. The above-mentioned model was dependent on Ricardo's Comparative Advantages theory. This model was deliberately selected, because some Far Eastern Asian Countries such as South Korea, Taiwan and Singapore had successfully adopted 'the export-oriented industrialization' for economic development. In this model, countries with cheaper relative cost advantage will become trade partners and regions with abundant factors are expected to profit. In addition, development of Turkish exports was supported by cheaper credit opportunities, tax deductions and/or exemptions, a floating exchange rate, and some other fiscal policies. As a result of the1980 regulations, the export capacity began to increase. Diversification of production, improvement of innovation and research and development increased not only in the domestic investment, but also the foreign investments in Turkey. In addition, the development of the Turkish production and export capacity, the adoption of a stable monetary policy and maintenance of a stable currency unit had considerable effects on the expansion of Turkish exports from Turkey.

One other important development for Turkish exports was the EU's Customs Union which was extended to the Turkish market in 1995. However, in the beginning, insufficient production operation techniques and lower quality of production and standards reduced the challenging power of Turkish products exportation from Turkey to the EU member countries, whilst imports from the EU increased in Turkey (see Table 1). But in a short period of time producers in Turkey adopted the EU regulations and standards into their production operation processes, which had considerable positive effects on Turkish exports. Due to this adoption, the export capacity of Turkish producers and other foreign markets into the EU steadily increased in the last decade.

In Turkey the amount of exports of agricultural products' is still not of considerable importance. The share of exportable agricultural products relative to imported products is still not sufficient, which causes a considerable deficit on trade balance and current account. The export of high technological production is still in progress and the share of total export capacity is not sufficient. At the beginning of the 1990s, in order to promote exports, Eximbank credits were introduced and used until 1998. At the end of the 1990s, the introduction of new fiscal policies caused economic construction, which reduced incomes, expenditures on private consumption and investments. In 1999, the earthquake negatively affected both production and trade capacity.

By the year 2001, continuous appreciation of foreign currencies against the Turkish Lira and economic difficulties forced the government to adopt a new economy program called "Turkey's Transition Program for a Stronger Economy", introduced in 2001. This program aimed "to reduce inflation and provide a favorable environment to revive growth. As well as involving a tight fiscal policy and comprehensive structural reforms, exchange rate targets were announced in line with the targeted inflation, and monetary policy was set in a framework that strictly linked liquidity creation to the inflow of external capital."[1] The program aimed to reduce inflationary pressure and increase capital inflow, thus relaxing the financial sector by increasing the amount of money supply in the market. The new program affected many macroeconomic parameters in a positive direction. As a result of this program, a

[1] Central Bank of the Republic of Turkey: Strengthening the Turkish Economy, Turkey's Transition Program, http://www.tcmb.gov.tr/yeni/announce/strengteningecon.pdf.

considerable increase in production capacity was observed but internal consumption stayed almost intact. And after the financial crises two main problems emerged in the Turkish economy. One of these problems was the higher interest rate, which continued to increase after the transition program dealing continuous damage to the financial structure of the banking system. Under these difficult circumstances which the Turkish economy faced, endeavors were undertaken to boost Turkish exports. This is done to promote an export-oriented industrialization model. However, economic developments were also observed in the agricultural sector, where the amount of exported products was in decline in total exports. However, considerable important regulations have been put into circulation for protection of the Turkish agriculture. Namely, maintenance of the agricultural sector is secured by the adoption of the Agricultural Reform Implementation Project (ARIP) between 2001 and 2005. Some market support measures such as, direct income support (DIS), have begun to be applied in Turkey to reduce the disparities between regions. However, export subsidies, import tariff, import/ export quotas, sanitary and phytosanitary measures, product quality and standards and some other measures continued to be applied to increasing the Turkish trade.

The above-mentioned developments had also considerable effects on consumer preferences, which changed in favor of Turkish products both inside and outside Turkey. The results of the above-mentioned important government regulations and maintenance of a sustainable economy policy had positive effects on increasing the export capacity from 2.9 billion USD in 1980 to 134.9 billion USD in 2011[2] (see also Table 1). However, until 2000, the foreign trade balance was contributed for increasing imports, which total imports amount was double the amount of exports. But the ratio of exports to imports between 1980 and 1999 continued to increase. After 2000, the export capacity increased and almost caught up with the imports. The exports total was only one fourth smaller than the total imports. After 2001 the amount of exports in the total trade capacity continued to decrease until 2007, but the ratio of exports to imports was in decline until then. After 2007 the ratio of exports to imports continued to increase until 2009. In 2010, a decline in exports in total trade capacity was observed. However, total trade capacity continues to increase (see Table 1).

It is also important to note that the single currency, which had been put into circulation in some EU member countries in 2002, made only a small contribution to Turkish exports. Over time the Euro appreciated in value against foreign currencies, especially for the Turkish Lira. An appreciation in value of the Euro had also made a small contribution to increasing exports to the EU market, because of the support measures applied by the community agencies to protect internal producers in EU countries. As mentioned above, similar measures and protection were observed in Turkey where a higher import tariff prevented manufacturers of cheaper products accessing the Turkish market. Such protection was a hindrance both for producers and consumers inside and outside the internal market, as this created an unfair market share for some domestic producers.

Table 1. Turkey's foreign trade

Years	Exports (Bn/$)	Imports (Bn/$)	Balance of foreign Trade (Bn /$)	Balance of foreign Trade (Bn/$ %)	Ratio of Exports to Imports (%)
1980	2,91	7,91	-4,310	-5,0	36,8
1987	36,7	27,5	-3,967	-3.9	72,0
1990	12,95	22,30	-9,342	-9,4	58,1
1995	21,63	35,71	-14,071	-14,1	60,6
1999	26,58	40,67	-14,084	-14,1	65,4
2000	27,77	54,50	-26,727	-26,7	51,0
2001	31,33	41,40	-10,064	-10,1	75,7
2004	63,17	97,54	-34,372	-34,4	64,8

[2] Report on the Evaluation of Turkish Export and Export Subventions given by State, MARKA Doğu Marmara Kalkınma Ajanı, 2011 Marka Yayınları serisi, Http://www.marka.org.tr.

Years	Exports (Bn/$)	Imports (Bn/$)	Balance of foreign Trade (Bn /$)	Balance of foreign Trade (Bn/$ %)	Ratio of Exports to Imports (%)
2005	73,48	116,77	-43,297	-43,3	62,9
2008	132,03	201,96	-69,936	-69,9	65,4
2009	102,14	140,93	-38,785	-38,8	72,5
2010	113,88	185,54	-71,661	-71,7	61,4
2011	134,971	240,834	-105,862	-105,8	56,0

Source: Turkish Statistical Institute (TUİK), Statistical Indicators 1923- 2011 in table 16.1 Imports and Exports p.477-478

Note1: Exchange rate has been taken TL/$ for 1923-2004 and TRY/$ for year 2005 and after.

Note2: Data unit values for the years 2005, 2006, 2007 and 2008 are given as TRY.

Note3: From 1.1.2009, TRY expression is changed to TL.

3. Theoretical perspectives of free trade

One important reason for free trade is the increasing impact of multinational firms on world politics and economics. In the past, international trade depended on international relations between politicians. In the last decade the increasing role of multinational firms reduced the role of national states in world economy and politics. The new world order is directly related to the theories of world politics.

There have been three main approaches to world politics: "Realism on the power relations between states, liberalism on a much wider set of interactions between states and non-states actors and world system theory on the patterns of the world economy."3 Liberalism affects the world's economy, social, cultural and also political events. Neo-liberal economics empowers and enriches big business, especially multinational companies (MNC's). Governments' debt reduction policies shift income and wealth from wages to profits. The reaction to the EU's economy policies, which reduce the wages and increase the profits of multinational companies, is the proof of income shift from wages to profits. However, in free but fair trade it is also important to maintain the welfare of the nations. Increasing market capacity in international markets is based on a higher challenging power and the competition capacity of MNC's. Trade capacity and exports will be enlarged with lower production costs and prices and higher quality products with considerable promotion and marketing techniques designed to capture a sufficient market share. On the one hand, lower production costs, which are the realized results of lower wages, will create a problem in maintaining a sustainable free but fair trade. On the other hand, reducing product prices results in the devaluation of the domestic currency; this will contribute to an increase in the export capacity. However, the result of this devaluation is that it produces some other inevitable problems which must be considered, such as welfare loss for consumers, an increased burden on debtors who borrowed foreign currency and an increase burden of those producers who are using foreign input.

Therefore, reducing wages is one of the important tools to increase competition. But it is also important to note that, "a comparison of countries' competitiveness will be done more accurately if the unit labor cost of production is considered instead of labor cost (wages)"4. Because reducing the unit labor cost of production contributes to the maintenance of considerable productivity in the production operation process. This implies that considerable productivity in production is an important tool in increasing competition and reducing the current budget deficit in economies. In Germany, labor wages are very expensive compared to other countries' wages. "In comparison to China's population, which is about 1.5 billion, Germany's population is about 84 million. Although Germany's current budget surplus was about 190 billion USD; against this China's budget surplus was about 260 billion USD in 2011."5

[3] Baylis, J.and Smith, S. The Globalization of world Politics. Oxford University Press, Oxford, 1999, p.6.

[4] Hürriyet newspaper, Ege Cansen: Oyunun Kuralı 'Krizde Her Çözüm Milli Gelirin Yeniden Dağılımına Çıkar' February 4th 2012, p.8.

[5] Hürriyet newspaper, Ege Cansen: Oyunun Kuralı 'Krizde Her Çözüm Milli Gelirin Yeniden Dağılımına Çıkar' February 4th 2012, p.8.

Germany's higher unit labor cost of production is the reason for a higher challenging power in the international market and a higher budget surplus. It is important to note that an increase in current budget surplus will increase a nation's welfare as well. It is obvious that the unit labor cost is more important than wages. It must be considered by governments as an important issue for controlling both the product prices and consumers' welfare. Governments' economy policies mostly concentrate on employee wages; however, it is also important that the unit labor cost of production be taken into consideration. Calculation of the unit labor cost, as above-mentioned, will considerably increase the countries' productivity. By doing this calculation of productivity the contribution to their GDP can be more accurately calculated. Assessing the cost of labor only is not sufficient to compare countries' competitiveness. The increasing profits of MNC's have made less of a contribution to increasing the GDP of member countries, because incorrect calculations of labor costs and the amount of profit included in the GDP were mostly realized at a lower level and as a result of this, the welfare of the country has been incorrectly estimated.

In fact, higher GDP and GNI per capita are the indicators of economic development. However, political parties' interests or preferences sometimes affect the governments' decisions. In many countries, politicians avoid reducing the income of the voters. Decline in national income is the indicator of welfare and wealth loss, and this means that politicians do not readily use this option, because income reduction has also meant the loss of voter support. In Greece, for example, the GNI per capita is rather high, but economic problems and fiscal difficulties are well-known current issues. The reason for this higher GNI per capita and inefficient economic performance and fiscal problems is probably maintained by politicians who want to secure their voters support.

The above-mentioned problems cause an unfair distribution of wealth. This creates difficulties in the distribution of incomes and increases the governments' budget deficits in many countries. In some EU countries, financial support for producers has increased the government's burdens in the last decade.

3.1. Effects of the exchange rate on free but unfair trade

In international trade the exchange rate effect is assumed to be realized "when domestic interest rates raise due to an expected increase in inflation the domestic currency depreciates"[6] It is obvious that depreciation of domestic currency against foreign currencies is either realized by inflation or intervention into the fiscal sector through the devaluation of the domestic currency. Both applications are supposed to contribute to increasing the export capacity and savings account by increasing the interest rate. In Turkey, the past nine devaluations have been made by governments between 1970 and 2010. However, neither devaluation nor higher inflation and interest rate made any considerable contribution to an increase in the export capacity. In those days, Turkey's foreign trade policy was concentrated on internal market regulations, but the foreign countries' trade regime was neglected. Although in EU countries, where Turkish trade considerably increased in a given period, several support measures and regulations were implemented to reduce exports of non-member countries. In particular, the Common Custom Tariff (CCT), direct payments, export subsidies and sanitary and phytosanitary measures reduced the access of non-member countries and Turkish producers into the EU markets. In the EU artificially increased product prices, due to support measures, caused an increase in the general price level and led to a trade distortion effect. A consequence of this trade distortion effect which was defined by Viner, was that some lower cost production of exportable commodities in third world countries are replaced by inefficient products of the home country, whereas currency depreciation or the application of support measures caused a price increase for imported products from third world countries. Such resource allocation between Turkish producers and EU producers is not consistent with fair trade which is mostly dependent on the comparative advantages theory, which states, that the relative cost advantage must be considered an important factor when becoming a trade partner. And it is also realized in the EU and several reforms and regulations considerably reduced the support measures.

[6] Mischkin, F. (2002). The Economics, Money, Banking, Financial Markets. Sixth Edition, Addison Wesely, Boston, p.170.

However, although Turkey became a member of the Customs Union in 1995, sanitary and phytosanitary measures and some other irrelevant measures still remain on the EU's agenda and prevent enlargement of trade capacity for Turkish producers in the EU markets. Since free but fair trade is dependent on the comparative advantages theory (Ricardo, D.), it is therefore necessary to verify whether or not the theory of comparative advantages still has unquestioned importance for fair trade relative to other international trade theories.

This question can be either empirically or theoretically answered. The theoretical answer can be a conclusion in favor of the comparative advantages theory, for the reasons explained below.

Clarification is given below of the theoretical perspective, which is, that the comparative advantages theory is of major importance in defining free but fair trade, i.e. price support for the sustainability and equity of traders in order to decrease trade distortion. And empirical evidence shows that trade distortion occurs, when some tariff and non-tariff trade measures applied for protecting the internal producers. And results of this trade capacity between internal producers are increased, whilst trade capacity of external producers is assumed to be distorted (see also Viner's Customs Union Theory).

International trade can be explained by the comparative advantages theory (Ricardo). Firstly, this theory is based on free trade and perfect competition. Secondly, comparative costs are related to technological advantage, because such an advantage also plays an important role in becoming a trade partner. And thirdly, this theory depends on the lower relative cost of advantage on trade which allows countries to compete freely in the market on their lower relative cost advantage as a trade partner. As stated by Gilpin "Most economists believe that the international community should concentrate its efforts on creating an open multilateral world economy rather than on making regional arrangements, because a world economy based on the principle of comparative advantages and national specialization would not only produce superior economic benefits but an open and non-discriminatory economy would also reduce international economic friction and perhaps even promote peace."[7] This explanation is obviously of major importance in the argument that the comparative advantages theory supports free but fair trade.

3.1.1. Depreciation of the currency and impact on trade

Depreciation of the currency increases product prices and prevents cheaper imported product access into the home market, but also causes higher prices in the domestic market, which implies inflation. Increasing prices has also meant an increase in the level of money supply. And increasing product prices on the one hand reduce the purchasing power of domestic consumers and reduce real income. This causes an increase in imported product prices, because the decreasing value of the domestic currency reduces the exchange rate value against foreign currencies.

The effects of the currency depreciation on importers cause an increase on the burden of imports in the domestic market. Effects on consumer: Results in inflation imported product prices becoming more expensive and higher import prices reduce imported product consumption in the domestic market. Effects on export: Results in depreciation of the currency as exports of domestic production are expected to increase. Effects on trade balance: An increase in export capacity is expected to reduce the deficit on trade balance. Effects on producers: Depreciation of currency contributes to an increase in value over production and of producers' reserve capital amounts. As in Turkey in the1980s, an increase in the reserve capital amount is observed. This implies that the depreciation of currency causes net income transfer from consumers to producers. And this will increase the abyss between rich and poor. Effects on production: If production is based on imported input, it is expected that production will become expensive. As observed in Turkey, many finished goods are produced by using imported inputs. This implies that the application of inflationary policies may not only reduce the amount of imports, but may also reduce exports. Therefore, the selection of political instruments as a tool for contributing to economic development must be analyzed carefully.

[7] Gilpin, R. The Challenge of Global Capitalism. Princeton University press, New Jersey, 2000, p.338.

3.1.2. Appreciation of the currency and impact on trade

Appreciation of the currency is realized when the domestic real interest rate rises. This implies a decline in money supply which will reduce the general price level. As a result of a low level of money supply, the exchange rate is expected to increase the value of the domestic currency. The effects of currency appreciation cause an important change in internal and foreign markets, because appreciation increases the value of domestic currency, which means it is worth more in terms of foreign currency.

Effects on consumer: Appreciation of the domestic currency increases the purchasing power of internal consumers, due to an increase in real income. And as a result of deflation, imported product prices will become cheaper for internal consumers. Effects on importer: Imported product prices will become cheaper. An increase in value of domestic currency reduces the burden on importers in the domestic market who import from (foreign countries) abroad. Effects on Export: The increasing value of the domestic currency means exports will become expensive and this will reduce the exported product capacity, because less exported products will be demanded. This will reduce the export amount of Turkish producers (domestic producers) whilst imports increase. Effects on trade balance: A decline in exports and an increase in imports is expected to increase the deficit on trade balance, which will also lead to lower growth.

3.2. Inflation and interest rate

From a theoretical aspect it is assumed that "lower price level reduces the interest rate, encourages greater spending on investment goods and thereby increases the quantity of goods and services demanded. Conversely a higher price raises the interest rate, discourages investment spending and decreases the quantity of goods and services demanded."[8] Price increase is also an indicator of excessive money supply in the economy. And a higher interest rate is one of the important instruments for controlling and reducing the excess money from the market. As stated in Keynesian economics, on the one hand, "people will sacrifice the ability to earn interest on money that they want to spend in the present, and that they want to have it on hand as a precaution. On the other hand, when interest rates increase, they become willing to hold less money for these purposes in order to secure."[9] Since high inflation has a positive effect on increasing the interest rate and export capacity, then it is assumed that price increases will stimulate the interest rate and a higher interest rate will contribute to an increase in savings - which in Turkey is very low. The amount of savings is estimated at less than 15% in total reserves and it is expected to increase up to 25 % to allow for better allocation of resources. Therefore, the interest rate plays an important role in controlling the money supply and slows down the economy. This is obviously a continuous process in the economy.

It is clear that growth and stability are major problems of the economy, and economic stability is not an easy issue. As experienced in the 1980's, in the era of Thatcher in UK and Regan in the USA, a nation's welfare was dependent on economic stability. And due to this approach, globalization and the concept of a New World Order were introduced as important aspects of economic development and increased welfare in the nation. The New World Order is based on three factors, of which stabilization, privatization and liberalization are accepted as important contributors to economic welfare and prosperity, with economic stability being mostly achieved by stable prices in the market. However, at that time such price stability and lower inflation was not observed in Turkey (See table below). Until 2000higher consumer prices were observed in Turkey. Neither economic stability, nor privatization secured economic growth. Turkey's export capacity continued to increase between 1980 and 2010. Although inflation and important price changes between these periods made a small contribution to an increase in export capacity, (as can be seen in Tables 1 and 2), decreasing domestic prices, or in other words, appreciation of the Turkish Lira had no negative effects on the development of Turkish exports.

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[8] Mankwin, N.G. Principle of Economics, Harvard University, South Western Cengage Learning international student edition, US 2009, p.747.

[9] Keynes, J.M. The General Theory of Employment, Interest, and Money, Atlantic Publisher and Distributor, New Delhi Chapter 13: The General Theory of the Rate of Interest, 2008, p.148.

Table 2. Inflation Rates Currency (unit: Turkish Lira's) and exchange rates between 1980-2010

Consumer price index The rate of changes -previous year's December values considered-	
1978	34.2
1979	77.7
1980	93.0
1982	33.2
1984	70.7
1986	48.1
1990	69.4
1994	215.0
1997	81.7
2001	76.8
2002	24.5
2003	12.6
2004	11.6
2005	2.7
2006	19.2
2007	9.4
2008	14.5
2009	5.7
2010	3.27

Source: North Cyprus and Turkey's State Statistical Institutes – Statistic and Research Department.

Despite these positive developments in Turkish trade, the deficit on current account in Turkey continued to increase between 1970 and 2010. However, the development and growth rate, with the exception of years 2001 and 2009, continued to increase considerably (see Figure 1 and Table 3). But, as mentioned above, price stability alone is not sufficient for a stable economy. Price stability is requires support from fiscal policies designed to further economic stability. "Fiscal instability can be related to the three factors which may be observed in the economy. These are: An enormous increase in individual wealth, which is not related to the development of the national income and national savings, budget deficit, which causes an increase in the public debt and finally, a continuous increase in the current account deficit,"[10] They are considered important factors which affect and change the stability and economic development of a country. Inefficient economy policies, that affect and slow down economic growth, may reduce the Gross Domestic Product (GDP), which causes a reduction in governmental revenues, and in some other parameters such as saving, investment, employment, trade capacity etc. The occurrence of these negative effects in an economic recession is inevitable. And in recession, the production and export of goods and services will be less. Especially in Turkey, where considerable amounts of input and energy are imported from third countries, the deficit on current account continuously creates a problem in the balance of payments and reduction in trade capacity and loss of producer gain and consumer welfare continues.

[10] Hürriyet Newspaper: article: "İstikrarsızlaştırma" Ege Cansen, March 31st, 2012, p.10.

Source: The Economist, June, 14th 2013 *The New young Turks*, article p.21.

Figure1. Turkey's GDP and unemployment rate between 2000 and 2013

In Turkey during 1980 and 2000 an increasing rate of inflation is observed, and in this period the GDP was not stable and in most years was in decline (see Table 3 below). But, in a given period trade capacity increased, as indicated in Table 1. In 1980, exports were 2.910,122 billion US dollars, which increased by 28.7% and the import capacity was 7.909,364 billion US dollars which increased by 56% in 1980. And in 2001 the export capacity rose to 31.334,216 billion US dollars, which was an increase of 12% compared to the previous year's export capacity, while the import capacity decreased to 41.399,083 US dollars. Of which reduced by 24% compare to the previous year import. In 2011, exports increased to 134.971,545 billion US dollars, which represented an 18% increase compared to the previous year, while in the same year the import capacity increased to 240.834,392 Billion US dollars, which showed an upward development of 29.8%.

The improvement of Turkish trade in a given period is an indicator that inflation is not the only factor in increasing trade capacity. Since 2001, the Turkish Lira has been a stable currency and the effects of inflation on Turkish exports contributed less to an increase in Turkish exports. Then it is obvious that a rise in export capacity cannot be based on the inflationist policies, because before 2001, where hyper-inflation was observed in the Turkish economy, export capacity continued to increase, whilst import capacity also considerably increased. Therefore, development of Turkish trade is dependent on lower cost of production, and successful Turkish politics and foreign policies and trade regimes are applied by Turkish governments in order to move closer to world politics and economics. But part of this success comes from the Turkish producers and businessmen who engaged in considerable bilateral business agreements with the aim of expanding Turkish trade.

Table 3. Turkey's GDP Real Growth Rate between 1980 and 2001

Year	Gross domestic product, constant prices	Year	Gross domestic product, constant prices
1980	-0.779	1991	0.926
1981	4.365	1992	5.984
1982	3.429	1993	8.042
1983	4.758	1994	-5.456
1984	6.823	1995	7.19
1985	4.258	1996	7.007
1986	6.941	1997	7.528

Year	Gross domestic product, constant prices	Year	Gross domestic product, constant prices
1987	10.027	1998	3.092
1988	2.121	1999	-3.365
1989	0.253	2000	6.774
1990	9.255	2001	-5.697

Source: http://www.indexmundi.com/turkey/gdp_real_growth_rate.html

4. Export-oriented growth

In the 1970's, economic policy was based on import substitution and a closed economy, and the Turkish government's trade policy was concentrated on imports substitution and production for the domestic market. After 1980, following Thatcher's and Regan's three important policy changes, namely, stabilization, privatization and liberalization in the world economy, Turkey's trade policy was also affected and changed by new cabinets, after the military intervention of September, 1 980.

The export-oriented development model was introduced and many political and democratic changes realized for the adoption of a liberal economy. However, the implementation of the liberal economy model brought many problems, one of which was fictitious exports. As a result of these fictitious exports, the deficit on current account increased considerably and after 2000 this deficit continued to increase. This is still one of the country's most important fiscal problems - preventing a current account deficit and increasing the saving amount in the Turkish economy. For this reason, devaluation of the Turkish lira and an increase in nominal interest rate is on the government's agenda in order to promote saving. However, a rise in real interest rate must be expected, because, in the long run, higher nominal interest rates will contribute to higher inflation and depreciation of the Turkish lira, and this will contribute to an increase in the country's foreign debt amount. However, in the long run, real interest rate must be increased in order to lower inflation and raise domestic currency. By doing this the foreign debt total will decrease and the welfare of consumers and gain for producers who are using foreign input, will be increased.

In Turkey, in the long run, a sharp reduction in real interest rate is targeted. As one of the journalist and financial analyst Y. Bulut stated, "Interest is haram" (anything forbidden by the Islamic religion) and continued", interest is one of the most important problems which negatively affected the performance of the Turkish economy between 1940 and 2001."11 This is actually a more fundamentalist approach, where interest is assumed to be a haram profit, and suggests that people may increase their incomes through working, not through interest. In fact, the current government's attention is also concentrated on developing a better and fairer economy and equalizing the interest rate. The inflation rate is also on the cabinet's agenda. It is clear that equalization of the interest rate and inflation rate is a possible advance solution for the protection of both producers' gain, and consumers' welfare. By doing this, on one side, the consumer will be protected from higher inflation and on the other; investors will be able to borrow at an acceptable interest rate, thus promoting investments.

A deficit on current account and a decrease in exports relative to increasing imports creates a considerable problem for Turkish trade. Some political changes have been made in the regulations, but the export-oriented trade regime remained intact between 1980 and 2010. Maintenance of export-oriented trade policy caused some problems which continue to increase the burden on Turkish trade in the last decade. As stated in The Economist, "Turkey has not just overheated. It has a growing competitiveness problem and a dangerous addiction to the riskiest types of foreign capital[12]." "Last year, in Turkey, according to the Central Bank's report in 2012, the current account deficit was 50 billion 186 million dollar which was 10% in excess of the GDP in 2011. And for the last 7 months of 2012, the

[11] Bulut, Y. and Haramdır, F. Cumhuriyet Newspaper, March 29th, 2012.
[12] The Economist, April 7th, 2012. Message to Ankara, p. 15.

current account deficit dropped to 34 billion 462 million dollars[13] ". In spite of considerable reduction in the current account deficit, this deficit would be a considerable problem for any economy nowadays; the Turkish cabinet is still struggling to reduce the deficit in current account.

Fiscal problems and debt crises affecting many economies both developed and developing countries and the balance of trade is the indicator of trade flow in the current account between countries. In a nation, the balance of trade is the difference between sales of exports and the cost of buying imports. "The balance on goods and services (or net export for short) is a major component of aggregate demand for expenditure on the reporting country's aggregate output".[14] However, the current account together with the financial account is the two most important parts of international transactions, relative to the capital account. And most of these problems are observed stem from deficits on current account in many economies. Last year similar problems caused serious debt crises in several EU countries, such as Greece, Portugal, Italy, Ireland, and Spain, the so called PIIGS countries, and these crises later spread to other member countries, Slovenia, Slovakia, Malta, Luxembourg and Cyprus.

In fact, such a fiscal problem in the nations of the world is not deliberately created, but it is a topic under discussion that many of the most powerful economies in the EU, especially Germany, France and some other countries' global interests such as energy needs, increasing market share and profit expectations contributes for creation of such economic problems. Consequently, smaller members become more dependent on the larger members' sovereignty in economic and political matters.

It is also well known that the gap between rich and poor has been deepening in the last two decades. According to UN reports it is suggested that "the gap between richer and poorer households has widened since the 1990s."[15] The profit-oriented MNC's expectations and increasing competition to capture a higher market share is contributing to this result. Increasing energy needs compel developed countries to become more offensive to those countries where energy resources are located. It is obvious that most of the energy resources are located in the southern part of the world, especially in countries in the Middle East. For this reason, the interest of developed countries in these countries has increased in the last two decades. One of these economies is Turkey, with a huge market and a growing economic performance there has been an increase in interest in Turkey from the developed nations. Turkey is also included in the MIST countries where Mexico, Indonesia, South Korea and Turkey are considered. As is known, BRIC was the first group introduced as potential countries which were expected to take a leading position in world economics. However, Turkey's higher economic performance which is assumed to be achieved by its growing export capacity, does not covering its trade balance or deficit on current account, because energy and several inputs (about 70 per cent) used in production operation process are imported. And it is obvious that the development of exports has also meant the development of imports. Therefore, Turkey's current account deficit is expected to continue, unless the country's use of foreign energy and input does not get replaced by domestic resources.

According to recent data published in Trading Economics "Turkey recorded a Current Account deficit of 8170 USD Million in April of 2013. Current Account in Turkey is reported by the Central Bank of Turkey. Historically, from 1984 until 2013, Turkey Current Account averaged -1125.18 USD Million reaching an all-time high of 1132 USD Million in September of 1998 and a record low of -9518 USD Million in March of 2011."[16] Since the current account is an important indicator of the debt problem and it is calculated as exports minus imports of goods and services - and in Turkey a higher amount of exported goods are produced using foreign energy and input - then it is very difficult to reduce the amount of debt in Turkey in a short period of time. And the fiscal deficit, which is assumed to be very high, and has reached a risky level, will in the near future cause a considerable depreciation of domestic currencies. This is expected to happen because Turkey's saving account is very low (about 15 percent).

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[13] Sabah newspaper. September 11th, 2012. Cari Açık Belli oldu- Current Account is published.

[14] Chacholiades, M. International Economics. McGraw-Hill Companies, New York, 1990, p.292

[15] UN news Centre. Income gap between rich and poor is huge and growing, warns UN report. Available at http://www.un.org/apps/news/story.asp?NewsID=28590&Cr=INCOME&Cr1=ILO,.

[16] Turkey Current Account. Available at http://www.tradingeconomics.com/turkey/current-account,

It is also expected that the devaluation of the Turkish currency increases prices and interest rates in order to raise the saving amount above 20% for a better allocation of resources and for the creation of some resources to reduce the deficit on current account.

It is obvious that the Turkish economy has developed in the light of exports. However, neither inflation nor the exchange rate mechanism, were used as important instruments to increase trade capacity and GDP between 1980 and 2010 (see Tables 1and 3). In addition, neither in higher inflation, nor in stable price periods, were enormous increases on exports observed, but continuous improvement on export capacity was achieved.

It is also important to note that the development of the Turkish economy has also had positive effects in Turkey on other parameters, such as imports, growth rate, employment and national welfare.

Conclusion

Turkey's export and import capacity between 1980 and 2010 varies from one year to another. An increasing share of exports in total international trade plays an important role in reducing the deficit amount of trade balance. As indicated in Table 1, in 2001 and in 2009, a considerable increase in exports is observed. However, as explained in the theoretical part, it is assumed that exchange rate plays an important role in increasing or decreasing trade capacity. But in 2001, where the USD appreciated almost twofold against the Turkish Lira, Turkish exports had only slightly increased. Similarly, in 2008 where the TL appreciated as much as the USD, there was again a small increase in Turkish exports (See Table 2). In addition, considerable improvement in the GDP occurred after 2000 when the domestic currency became more stable and appreciated against foreign currencies. Expansion of export capacity cannot only be dependent on the exchange rate regime. Depreciation of currency contributes to the promotion of the country's exportation of goods and services to foreign markets. But product price alone cannot change market capacity. However, devaluation of the domestic currency has several important effects on economic indicators. Some of these important effects are given below:

- Devaluation causes some resource transfer from domestic consumers to domestic producers,
- It reduces the domestic consumer purchasing power;
- It reduces producer gain for those who are using foreign input and energy in the production operation process;
- It increases the consumers' utility in foreign countries;
- Depreciation of domestic currency which implies appreciation of foreign currency - it is expected that the appreciation of foreign currency increases prices and interest rate in order to increase the saving amount to ensure a better allocation of resources;
- It reduces the burden of debtors who borrowed with domestic currency;
- Depreciation of currency will stimulate the money supply in circulation, and an increase in money supply causes an increase in interest rate;
- Depreciation of currency increases people's interest in holding bond and stock papers.

Since 1990 the percentage of Turkish exports in the total trade has been around 60 percent. The increasing inflation rate in 1990 did not influence and increase amount of exports. However, the share of exports in total trade stayed unchanged between 2000 and 2010, when the inflation rate fell sharply. As is known, a decline in the general price level caused an appreciation of the TL against foreign currencies and it is supposed that an appreciation of the domestic currency decreases the export capacity. However, both exports and imports continued to increase between 2000 and 2010. In short, inflationist policies, or appreciation of the Turkish currency did not cause a considerable change in exports. But, as stated in the theoretical part, appreciation of currency or devaluation of currency is assumed to be causing a considerable change in export capacity. Therefore, the relationship between inflation, exchange rate and export of goods is becoming questionable. Because, in theory, it is assumed that either an increasing amount of inflation or the decreasing value of domestic currency (depreciation of domestic currency) is expected to increase the export amount. However, it is also important to note that price changes alone are not sufficient to increase market share. First of all, all goods and services are not perfect substitutes. And the Consumer Price Index (CPI) items are also not identical, homogeneous and equivalent to each other. Therefore, substitution of goods and services cannot be solely dependent on price changes. In this study, it has been shown that neither inflation, nor exchange rate causes a considerable increase in exports Furthermore; increasing trade capacity in Turkey is assumed to be created as a result of factors other than inflation. These factors can be summarized as given below:

- Adoption of the EU regulations and standards in Turkish production operation processes, increased the production and export capacity;
- Adoption of the EU's sanitary phytosanitary measures;
- Improvement of safety production methods, environmentally- friendly production, labelling, wrapping, warranties, hygienic standards etc.;
- Reduction / removal of tariff / non-tariff trade barriers, results of Customs Union membership realized between EU and Turkey;
- Use of lower cost production technique, which contributes to catch up the relative cost advantage as explained in Ricardo's comparative advantages theory;
- Abundant resource advantage in certain sectors increased trade capacity,
- Transportation cost advantage - location of the factories is near to the both eastern and western countries markets;
- Increasing know-how and innovation technologies;
- Economic convergence effect.

The last factor, economic convergence, plays an especially important role for Turkish producers, as is known, Turkey stands in the middle of east and west. This means producers can easily adopt the new technologies and innovations from western countries and catch up on the developed countries high tech production techniques and marketing strategies. As a result, this adoption of new techniques, achieved faster than in the less developed countries, increases the production capacity and exports. This is achieved by faster adoption of new technologies, lower cost production, results of cheap employee and abundant input advantage, which all causes lower product prices, yet maintains high quality and standards in production operation and the marketing process. As is explained in the Neo Classical Convergence model, less developed countries with catch up effect increase the challenging power in international market and welfare of the nations.

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AN EARLY WARNING SYSTEM FOR INFLATION IN THE PHILIPPINES USING MARKOV-SWITCHING AND LOGISTIC REGRESSION MODELS

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Abstract:

With the adoption of the Bangko Sentral ng Pilipinas (BSP) of the Inflation Targeting (IT) framework in 2002, average inflation went down in the past decade from historical average. However, the BSP's inflation targets were breached several times since 2002. Against this backdrop, this paper attempts to develop an early warning system (EWS) model for predicting the occurrence of high inflation in the Philippines. Episodes of high and low inflation were identified using Markov-switching models. Using the outcomes of the regime classification, logistic regression models are then estimated with the objective of quantifying the possibility of the occurrence of high inflation episodes. Empirical results show that the proposed EWS model has some potential as a complementary tool in the BSP's monetary policy formulation based on the in-sample and out-of sample forecasting performance.

Keywords: inflation targeting, Markov switching models, early warning system.

JEL Classification: C2, C22.

1. Introduction

Price stability or the condition of low and stable inflation is a universal goal shared by monetary authorities all over the world. Price stability is important because empirical evidence shows that high and volatile rates of inflation distort the decisions that people make about consumption, investment, savings and production. These distortions, in turn, lead to inefficient allocation of resources, and ultimately contribute to slower economic growth. In addition, high inflation erodes the purchasing power of the domestic currency, thus affecting the lower-income households to a greater extent than any other sector of the society. Monetary authorities, therefore, help promote sustainable economic growth by keeping inflation low and stable.

Since January 2002, the Bangko Sentral ng Pilipinas (BSP) has adopted inflation targeting (IT) as its framework for monetary policy formulation. Under the IT framework, monetary authorities take a forward-looking view and calibrate their policy rates to manage deviations of future expected inflation or output levels from their respective targets. State-of-the-art statistical models provide monetary authorities reliable forecasts on the future path of inflation and output. The forecasts are complemented by the policymakers' forward-looking assessment of inflation pressures. Risks to the inflation outlook, both upside and downside are assessed using the widest possible array of information and tools.

With the adoption of the IT framework, the BSP was able to bring down the mean of inflation from historical average. Cruz and Dacio (2013) estimate that average inflation (using 2006-based series) went down from 6.9 percent in the seven years before the IT was adopted to 4.4 percent over the period 2002 to 2012. Nonetheless, the BSP's inflation targets were breached in seven of the 11 years that the IT framework had been adopted in the Philippines. Since there is no single model that could accurately forecast the inflation path or address all policy issues concerning monetary authorities, the BSP periodically reviews its existing suite of forecasting models as well as develop new tools to keep up with new developments in modern monetary economics. In addition to forecasting models, therefore, statistical models that could help policymakers measure and assess the risks to the inflation objective may prove to be useful in the monetary policy formulation process.

This paper attempts to contribute to the literature by developing an early warning system (EWS) for predicting the occurrence of high inflation in the Philippines. The proposed early warning system model for predicting high inflation employs the limited dependent variable approach. Episodes of high inflation were identified using the Markov-switching model which allows the shift from a low inflation to a high inflation regime to occur endogenously rather than being imposed by the researcher. The paper then identifies a class of domestic and external macroeconomic indicators which have leading indicator properties for switching between inflation regimes.

The end-goal of the paper is to develop models that could help quantify the possibility of the future occurrence of high inflation. While the models are not intended to forecast inflation for some forecast horizon, they could complement the existing toolkit of the BSP in the assessment of the inflation environment and the risks to the inflation outlook.

The organization of the paper is as follows: Section 2 reviews some of the relevant research works on inflation regimes; Section 3 describes in detail the methodology adopted in the paper; Section 4 discusses the inflation indicators used in the model; Section 5 presents the empirical results as well as the evaluation of the proposed models; and the last section concludes.

2. Predicting regime shifts of inflation

A monitoring tool called the early warning system consists of a precise definition of a crisis and a mechanism for generating predictions of crises (Edison, 2003). The development of early warning systems for use in economic policy formulation relates mainly to the prediction of financial crises. There are various types of financial crises typically studied, including currency crises, banking crises, sovereign debt crises, private sector debt crises, and equity market crises.

However, the literature on the development of a EWS-like system to predict high and volatile inflation has been fairly limited. The studies which have attempted to do so use variants of Markov-switching models and limited dependent variable regression models. The macroeconomic variables considered as explanatory variables for some of these studies tend to be very limited as well.

In an early work, Evans and Wachtel (1993) analyze the sources of uncertainty that affects the dynamics of inflation and agents' inflationary expectations collected in surveys. On the assumption that inflation can either follow a random walk process or an autoregressive process, they note that that the switch between these two regimes explains the presence of discrete jumps in the US inflation during the postwar period. Simon (1996) of the Reserve Bank of Australia applies the methodology of Markov-switching models to describe the inflation process in Australia. He notes that the distinctive feature of the approach is the use of very simple equations for inflation within a framework that allows for discrete 'regime shifts' or shift points in time. Amisano and Fagan (2010) employ a similar approach in their analysis of the relationship between money growth and inflation. They develop a time-varying transition probabilities Markov switching model in which inflation is characterized by two regimes, high and low inflation. In the study, the probability of shifting from one regime to the other depends on a measure of lagged money growth.

Meanwhile, Landrito, Carlos and Soriano (2011) implement a univariate Markov-switching Autoregressive model to identify periods of high and low inflation over the period 1995-2009 in the

Philippines. The study shows that when the country is in a state of 'high' inflation, the average inflation rate is 6.64 percent while in times of low inflation, the average inflation rate is 4.43 percent. It is interesting to note that the study's estimated average inflation during the low inflation regime is on the upper bound of the current inflation target range of the BSP of 3-5 percent. This may be attributed to the fact that periods of high inflation prior to the BSP's adoption of the IT framework in 2002 are included in the analysis.

A recent work by Mitra and Erum (2012) proposes a different approach to setting up an early warning prediction system for high inflation. The proposed warning system uses historical values of a set of economic variables as inputs and builds an elitist genetic algorithms-based artificial neural network (ANN) model for quantifying the possibility of high inflation within a fixed period of time window. In building the neurogenetic model, the paper uses elitist generational genetic algorithms for optimizing the architecture of the ANN. The output of the proposed EWS is in terms of probability, quantifying the possibility of occurrence of an incidence of high inflation within a chosen period of time. Their results suggest a promising performance of the proposed neurogenetic warning system, which is capable of generating accurate early warning signals of an impending high inflation.

3. Model specification

This paper considers a qualitative response model in setting up an early warning system for high inflation in the Philippines. The approach is in line with the literature on early warning systems for the various types of financial crises.

3.1. Markov-switching model

In identifying episodes of high inflation, the paper employs the Markov-switching model which does not distinguish *ex ante* between high and low inflation episodes. The inflation process is described as being governed by two different regimes and the switches between them are based on a probabilistic process, so that shifts occur endogenously rather than being imposed by the researcher.

This study uses a two-regime MS-AR model in which the transition is driven by a two-state Markov chain. We let y_t be the inflation rate time series. Then, y_t follows a two-regime MS(2)-AR(p) model if

$$y_t = \begin{cases} c_1 + \sum_{i=1}^{p} \Phi_{1,i} y_{t-i} + a_{1t} \text{ if } S_t = 1 \\ c_2 + \sum_{i=1}^{p} \Phi_{2,i} y_{t-i} + a_{2t} \text{ if } S_t = 2. \end{cases} \quad (1)$$

The process $\{S_t\}$ assumes values $\{1,2\}$ to signify the regime at time t. In particular, $S_t = 1$ denotes a low inflation regime while $S_t = 2$ signifies a high inflation regime. The series $\{a_{1t}\}$ and $\{a_{2t}\}$ are sequences of iid random variables with mean zero and finite variance. The process $\{S_t\}$ is a stationary, aperiodic and irreducible Markov chain, defined by transition probabilities between the two states:

$$p_{ij} = p_{j|i} = P(S_t = j | S_{t-1} = i), \quad i, j = 1,2 \quad (2)$$

The probability p_{ij} refers to the probability that the Markov chain will move from state i at time $t-1$ to state j at time t. A small value of p_{ij} means that the model tends to stay longer in state i. Meanwhile, its reciprocal $1/p_{ij}$ indicates the expected duration of the process to stay in state i.

The process is assumed to depend on the past values of y_t and S_t only through S_{t-1}. When the process is in any given state, it may move to the other state in the next transition, or it may stay in its current state since the process $\{S_t\}$ is assumed to be irreducible and aperiodic. Franses and van Dijk

(2000) note that for the $p_{ij}s$ to define proper probabilities, they should be nonnegative while it should also hold that $p_{11}+p_{12}=1$and $p_{21}+p_{22}=1$.The transition probabilities can be written in the form of a transition probability matrix:

$$P=\begin{bmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{bmatrix} \tag{3}$$

Since only the time series of interest is observed, not the Markov process, the estimation of Markov-switching models are not straightforward. Following the discussion of Franses and van Dijk (2000), under the assumption that $a_{s_t,t}$ in Eq. (1) are normally distributed, the density of y_t conditional on the regime s_t and the information set I_{t-1} is a normal distribution with mean $\Phi_{s_t,0}+\sum_{i=1}^{p}\Phi_{s_t,i}y_{t-1}$ and variance σ^2,

$$f(y_t|s_t=j,I_{t-1};\theta)=\left(\frac{1}{\sqrt{2\pi\sigma^2}}\right)\exp\left\{\frac{-(y_t-(\Phi_{s_t,0}+\sum_{i=1}^{p}\phi_{s_t,i}y_{t-i}))^2}{2\sigma^2}\right\} \tag{4}$$

Given that the state s_t is unobserved, the conditional log likelihood for the t^{th} observations $l_t(\theta)$ is given by $l_t(\theta)=\ln f(y_t|I_{t-1};\theta)$ or the log of the density of y_t conditional only upon the history I_{t-1}. The density $f(y_t|I_{t-1};\theta)$ can be obtained from the joint density of y_t and s_t as follows:

$$f(y_t|I_{t-1};\theta)=f(y_t,s_t=1|I_{t-1};\theta)+f(y_t,s_t=2|I_{t-1};\theta)=\sum_{j=1}^{2}f(y_t|s_t=j,I_{t-1};\theta)\cdot P(s_t=j|I_{t-1};\theta) \tag{5}$$

To compute the density in Eq. (5), the conditional probabilities of being in either regime given the history of the process, $P(s_t=j|I_{t-1};\theta)$, needs to be quantified. In addition, Franses and van Dijk (2000) note that to develop the maximum likelihood estimates of the parameters in the model, we need to estimate three typesl of probabilities of each of the regimes occurring at time t. These are *forecast* (estimate of the probability that the process is in regime j at time t given all observations up to time $t-1$), *inference* or *filtered* (given all observations up to and including time t) and *smoothed* (given all observations in the entire sample) inference of the regime probabilities.

Hamilton (1990) notes that the maximum likelihood estimates of the transition probabilities are given by:

$$\hat{p}_{ij}=\sum_{t=2}^{n}P(s_t=j,s_{t-1}=\frac{i|I_n;\hat{\theta}}{\sum_{t=2}^{n}P(s_{t-1}=i|I_n;\hat{\theta})}) \tag{6}$$

where $\hat{\theta}$ denotes the maximum likelihood estimates of θ. In addition, the estimates $\hat{\theta}_j$ can be obtained from a weighted least squares regression of y_t on x_t, with weights given by the smoothed probability of regime j occurring.

An iterative procedure, which is an application of the Expectation Maximization (EM) algorithm developed by Dempster, Laird and Rubin (1977), may be used to estimate the parameters of the Markov switching model. In the EM algorithm, each of the iterations increases the value of the likelihood function, which guarantees that the final estimates can be considered ML estimates. An alternative maximization method is developed by Lawrence and Tits (2001). Called the feasible sequential quadratic programming, the method ensures that the parameters stay within the feasible region. Meanwhile, McCulloch and Tsay (1994) consider a Markov Chain Monte Carlo method to estimate a general MS-AR model. The MS-AR model can be generalized to the case of more than two states though the computational intensity increases rapidly.

3.2. Dependent variable specification

In specifying the dependent variable in the qualitative response model, one can take the "contemporaneous" approach in which the dependent variable takes the value 1 if HI_t is equal to 1 in the dating techniques discussed above. That is, if we let H_t indicate an episode of high inflation, then,

$$H_t = \begin{cases} 1, if\ HI_t = 1 \\ 0, otherwise. \end{cases} \tag{7}$$

An alternative approach takes a forward-looking view in which the contemporaneous variable H_t is transformed into a forward variable. This alternative model predicts whether an inflation crisis or an event of high inflation event will occur within the specific time period defined by the researcher.

3.3. Logistic regression model

In setting up the EWS model for inflation, we model the probability of being in the state of high inflation using the logistic regression model. Following the discussion of Kedem and Fokianos (2002), we consider a binary time series $\{Y_t\}$ taking the values 0 or 1 to denote a low inflation regime and a high inflation regime, respectively. We let $Z_{t-1} = \left(Z_{(t-1)1},..., Z_{(t-1)p}\right)'$ be the corresponding p - dimensional vector of past explanatory variables or covariates, $t = 1,...,T$ and refer to Z_t as the covariate process. It is also convenient to think of Z_{t-1} as already including the past values of the response variable $(Y_{t-1}, Y_{t-2},...)$. We denote by S_{t-1} the σ-field generated by $Z_{t-1}, Z_{t-2},...,$

$$S_{t-1} = \sigma\{Z_{t-1}, Z_{t-2},...\}. \tag{8}$$

In addition, let us denote by $\mu_t = E\left[Y_t | S_{t-1}\right]$ the conditional expectation of the response given the past. Our interest is the estimation of the conditional success probability:

$$P_\beta\left(Y_t = 1 | S_{t-1}\right), \tag{9}$$

where β is a p-dimensional vector, and S_{t-1} represents all that is known to the observer at time $t-1$ about the time series and the covariate information. According to Kedem and Fokianos (2002), the response process $\{Y_t\}$ may be stationary or non-stationary and the time dependent random covariate vector process $\{Z_{t-1}\}$ may represent one or more time series and functions thereof that influence the evolution of the primary series of interest $\{Y_t\}$.

To ensure that the model in Eq. (9) yields proper probability estimates, we need to choose suitable inverse links $h \equiv F$ that map the real line onto the interval $[0,1]$. We denote by π_t the probability of success given F_{t-1}. That is, we write Eq. (9) as:

$$\pi_t(\beta) = \mu_t(\beta) = P_\beta(Y_t = 1 | S_{t-1}) = F(\beta' Z_{t-1}), \tag{10}$$

where F is a continuous and strictly increasing function, returning a value which ranges from 0 to 1, β is a column vector parameter of the same dimension p as the covariate process Z_{t-1}.

The choice of the function F would determine the type of binary model. The typical candidate for F is the standard logistic cumulative distribution function which leads to the general logistic regression model given by:

$$\pi_t(\beta) = P_\beta(Y_t = 1 | S_{t-1}) = \frac{1}{1+\exp(-\beta' Z_{t-1})'} \quad (11)$$

where again, β is a column vector parameter of the same dimension p as the covariate process Z_{t-1}. Alternatively, the inverse link may be defined by $F \equiv \Phi$ where Φ is the standard normal cumulative distribution function. In empirical applications, logit and probit models typically yield similar results (Nyberg, 2010)[17].

Kedem and Fokianos (2002) provide a comprehensive discussion of the estimation β using maximum partial likelihood estimation (MPLE). They also show that the MPLE $\hat{\beta}$ is almost surely unique for sufficiently large N and as $N \to \infty$, $\hat{\beta} \to \beta$ in probability. An asymptotic $100(1-\alpha)\%$ prediction interval is given by:

$$\pi_t(\beta) = \pi_t(\beta) \pm z_{\frac{\alpha}{2}} \frac{f(\beta' Z_{t-1})}{\sqrt{N}} \sqrt{Z_{t-1} G^{-1}(\beta) Z_{t-1}}\,. \quad (12)$$

4. Data description

This section describes briefly the key variables of interest for an IT central bank. The sample period used in the estimation work is January 2002, when IT was adopted by the BSP, until December 2012.

4.1. Main Variable of Interest

Inflation rate is the annual rate of percentage change or the year-on-year change in the Consumer Price Index (CPI), which is a general measure of the average retail prices of commodities commonly purchased by households. CPI is reckoned from a base year and weighted by the consumption pattern or basket of the households. This study uses the year 2006-based inflation rate from the National Statistics Office (NSO).

4.2. Explanatory Variables

Considering the theoretical drivers of inflation as well as the modern practice of central banks in the monetary policy formulation, representative indicator variables are chosen from the following sectors: real output, liquidity, financial, and international commodity prices. Also included as an explanatory is the BSP's RRP rate, which is the BSP's main policy instrument in managing the inflation environment.

Real Output Indicator. The importance of output gap in inflation forecasting may be viewed as originating largely from the demand-pull theory of inflation. The output gap is the difference between actual real Gross Domestic Product (GDP) and potential GDP as a percent of potential GDP. A positive output gap is an inflationary gap, indicating that the growth of aggregate demand is outpacing the growth of aggregate supply. Meanwhile, a negative output gap is also called a recessionary gap which could result in deflation. A number of studies focused on the relevance of output gap in the BSP's monetary policy framework, including those of Debelle and Lim (1998), Yap (2003), and McNelis and Bagsic (2007). In this paper, the potential output estimate is taken to be the trend component of actual GDP, which is extracted using the Census X-12 time series decomposition.

Liquidity Indicator. From the monetary theory of Friedman, a measure of money supply called M3 or broad money liabilities or domestic liquidity is included as one of the key explanatory variables in this paper. Domestic liquidity has been traditionally included in inflation forecasting models, as discussed by Mariano, Dakila and Claveria (2003) and Cruz (2009). Sustained growth in liquidity could boost demand for goods and services and increase inflation. M3 includes national currency outside depository corporations, transferable deposits, other deposits, and securities other than shares included in broad

[17] Kedem and Fokianos (2002) also discuss log-log and complementary log-log as common links for binary time series.

money (deposit substitutes). This paper uses a measure called M3-to-GDP gap which is the percent difference between the seasonally-adjusted M3-to-GDP ratio and the trend of M3-to-GDP ratio obtained using Census X-12.

Financial Indicator. Asset prices, such as equity prices, are relevant for IT central banks as the build-up of asset market imbalances contributes to financial stability risks that can adversely affect both domestic economic activity and the inflation outlook. A surge in equity prices, for instance, may reflect the substantial inflow of foreign capital which could lead to overall increase in asset price inflation. In addition, vulnerabilities in the financial sector can weaken the traditional transmission channels of monetary policy. This paper uses the Philippine Stock Exchange Composite Index (PSEi) as the indicator variable for the financial sector. PSEi is a weighted aggregative index that provides a definite measure of the country's stock market performances.

Foreign exchange market indicator. The foreign exchange market is important for IT central banks due to its traditional impact on import prices. In line with the cost-push inflation theory, a weakening of the domestic currency increases the prices of imported goods and therefore could lead to higher inflation. This paper uses the peso-dollar rate or the foreign exchange rate, which refers to the guiding rate for the exchange of one US dollar (the country's intervention currency) for pesos. The foreign exchange rate is included as a key explanatory variable in the BSP's single-equation model (SEM) as noted by Cruz (2009) and in the structural long-term inflation forecasting model (LTMM) developed by Mariano *et al.* (2003). In this paper, the foreign exchange rate is expressed as the exchange rate gap or the deviation of the foreign exchange rate from the estimated trend using Census X-12.

International Commodity Prices. In accordance with the cost-push inflation theory, the world prices of key commodity imports, both food and non-food, have direct effects on domestic commodity prices. The benchmark prices of key cereal grains (in US$ per MT) and crude oil (in US$ per barrel), which are published by the World Bank in its monthly pink sheet reports, are used in this paper. International rice prices refer to the indicative price of Thai rice, 5 percent broken based on weekly surveys of export transactions while international wheat prices refer to the price of benchmark US wheat no. 1, hard red winter, export price delivered at the US Gulf port for prompt or 30 days shipment. Meanwhile, international oil prices refer to the price of Dubai Fateh crude oil.

Fiscal. As implied by the demand-pull theory of inflation, changes in fiscal policy can affect aggregate demand which may, in turn, affect either the output or the price level. Hence, excessive government spending relative to government revenue, which results in fiscal deficit, can be an upside risk to inflation. In this paper, government expenditure, expressed as a proportion of nominal GDP, is used.

BSP Policy Rate. The reverse repurchase (RRP) rate is the BSP's key policy rate. RRPs are typically contracted between the BSP and the banks, allowing the BSP to siphon off liquidity from the banking system on a temporary basis (as compared to the long-term effect of a change in reserve requirements). Increases in the RRP rate aim to temper inflation through the different channels of monetary policy.

4.3. Data transformation

Table 1 describes the estimation and transformation performed on the crisis indicators. Various types of transformations are applied to ensure that the indicators are stationary and free from seasonal effects. Seasonal adjustment (SA) and trend estimation are performed using Census X-12 ARIMA multiplicative procedure. In case the indicator variable has no seasonal pattern and is non-trending, its level form is maintained.

Table 1. Summary of variable estimation and transformation procedures

Indicator	Estimation/Transformation
Output Gap	The quarterly real GDP data is first transformed to monthly frequency using ECOTRIM. Then, the potential output is estimated by applying Census X12 time series to the SA GDP data. The output gap is estimated as the percentage deviation of the SA GDP from the trend.
M3-to-GDP ratio gap	The M3-to-GDP ratio is obtained by dividing the M3 level by the nominal monthly GDP, which is estimated using ECOTRIM. The procedure in estimating the output gap is then applied to the resulting M3-to-GDP ratio.
Stock Index	No SA, no detrending; Data are expressed in terms of natural logarithm.
₱/US$ Exchange rate	The series is expressed as deviation from trend.
International price of rice	No SA, no detrending. The series is expressed as 12-month percentage changes or as year-on-year growth rates.
International price of wheat	No SA, no detrending. The series is expressed as 12-month percentage changes or as year-on-year growth rates.
International price of Dubai crude oil	No SA, no detrending. The series is expressed as 12-month percentage changes or as year-on-year growth rates.
Expenditure-to-GDP ratio	The expenditure-to-GDP ratio is obtained by dividing the level of government revenue by the nominal annual GDP. The series is expressed in natural logarithm.
RRP rate	No SA, no detrending.

Headline inflation as well as the crisis indicator variables are tested for the presence of unit roots using the Dickey-Fuller-GLS (DF-GLS) procedure developed by Elliot, Rothenberg and Stock (1996). Following the suggestion of Schwert (1989), a lag length of 13 months, which is based on the formula $p_{\max} = (12 * (\frac{T}{100})^{\frac{1}{4}})$, is used. The results are shown in Table 2.

Table 2. Results of the test for stationarity

Indicator	DF-GLS Test Statistic*		Conclusion	Code for transformed stationary series
	Trend	Constant and Trend		
Headline Inflation	-2.40	-2.56	Non-stationary; I(1)	DINF
Output Gap	-1.91	-12.53	Stationary	YGAP
M3-to-GDP ratio gap	-8.17	-9.78	Stationary	M3
Stock Index	1.28	-1.66	Non-stationary; I(1)	PSEI
₱/US$ Exchange rate	-10.10	-10.42	Stationary	FOREX
Rice	-3.47	-3.54	Stationary	IRICE
Wheat	-2.93	-3.15	Stationary	IWHEAT
Dubai crude oil	-2.74	-3.35	Stationary	DUBAI
Revenue-to-GDP ratio	-0.77	-1.05	Stationary	EXPEND
Policy Rate	0.73	-1.87	Non-stationary; I(1)	POLICYRATE

*For the DF-GLS Test, the null hypothesis is presence of unit root (non-stationary). The critical values at the 10 percent significance level are as follows: Equation with intercept= -1.615075; Equation with trend and intercept=-2.7110.

5. Discussion of results

This section first describes the results of the inflation regime identification via a Markov switching model. This is followed by a discussion of the EWS model using logistic regression.

5.1. Regime Identification using the Markov-switching model

The estimation of the Markov switching model parameters was done in OxMetrics®. The inflation rate series is scaled, i.e., multiplied by 100, following the recommendation of Doornik and Hendry (2009). They note that it is often beneficial to scale the data prior to non-linear estimation.

Four two-regime Markov switching models, MS-AR(1) to MS-AR(4), are estimated using different lags. Model selection is performed using the Akaike Information Criterion (AIC) and various diagnostic tests, including normality and linearity tests. The results in Table 3 suggest that of the four MS-AR models, it may be prudent to exclude MS-AR(1) from the list of potential models. This is because it has relatively distant AIC value and the residuals appear to be not normally distributed. For the MS-AR(2), MS-AR(3) and MS-AR(4) models, the AIC values are close to each other with relatively behaved residuals. It may be noted also that linearity is rejected across models suggesting that the use of non-linearity adds to the linear, constant parameter model. Following the principle of parsimony, the MS-AR(2) is chosen to be the final model[18].

Table 3. Diagnostic Tests – MS-AR models

Tests		Models			
		AR(1)	AR(2)	AR(3)	AR(4)
AIC		10.440	10.207	10.216	10.192
Linearity test (Likelihood Ratio)	Test Stat	34.970	16.001	17.676	21.096
	P-Value	0.000	0.014	0.014	0.007
Normality test (Chi-Square)	Test Stat	7.175	3.594	1.459	0.929
	P-Value	0.028	0.166	0.482	0.930
ARCH 1-1 test (F)	Test Stat	10.186	1.427	0.654	0.008
	P-Value	0.002	0.234	0.420	0.930
Portmanteau test (Chi-Square)	Test Stat	71.085	62.325	48.568	37.825
	P-Value	0.000	0.004	0.079	0.386

The estimated parameters of the MS-AR(2) model are shown in Table 4. The values shown are rounded to the first three decimal places. Results show that the mean inflation in state 0 using the formula $c/(1-\Phi_1-\Phi_2)$ is 2.89 percent while that in state 1 is 5.75 percent. This implies that state 0 refers to a low inflation regime while state 1 refers to a high inflation regime. It is also worth noting that the average inflation for state 1 is higher than the upper bound of the current inflation target range of the BSP of 5 percent.

Table 4. Estimation Results of a Markov Switching Model with Two Lags for Inflation

State 0 (Low Inflation)					
Parameter	c_1	Φ_1	Φ_2	σ_1	p_{01}
Estimate	16.583	1.105	-0.162	33.254	0.116
Standard Error	11.460	0.114	0.112	2.912	

[18] Based on the diagnostic tests alone, MS-AR(4) model should be chosen because it is able to satisfy the assumption of no serial correlation, aside from normality and homoskedasticity. However, the resulting regime classification appears to be erratic with regimes lasting only 1 month. This may not be a reasonable result considering the inflation trends in the Philippines.

State 1 (High Inflation)					
Parameter	c_2	Φ_1	Φ_2	σ_2	p_{10}
Estimate	55.243	1.898	-0.994	32.141	0.246
Standard Error	17.040	0.096	0.104	4.428	

Based on the transition probabilities of the Markov-Switching model, the probability that the country will shift from a "high inflation" state to "low inflation" state $(p_{10} = 0.246)$ is about twice the probability of shifting from a low inflation regime to a high regime $(p_{10} = 0.116)$. Another interesting result is the expected duration of a state which is estimated as the reciprocal of the transitional probability. The expected duration of a period of low inflation is estimated to be 8.6 months while that of high inflation is about 4.1 months. This implies that, on average, once the Philippines enter a period of "high" inflation, it will stay in that state for about 4 months. The estimated duration of low inflation is about 9 months, more than twice that of high inflation. Overall, the relatively low probability of shifting from a low inflation regime to a high inflation regime and the duration of a low inflation regime lend support to the effectiveness of monetary policy in managing inflation in the Philippines.

The filtered, smoothed and forecast probabilities for each of the regimes are shown in Figure 1. It may be observed that low inflation periods dominate high inflation periods. This is consistent with the earlier results that the expected duration of low inflation is more than twice that of high inflation.

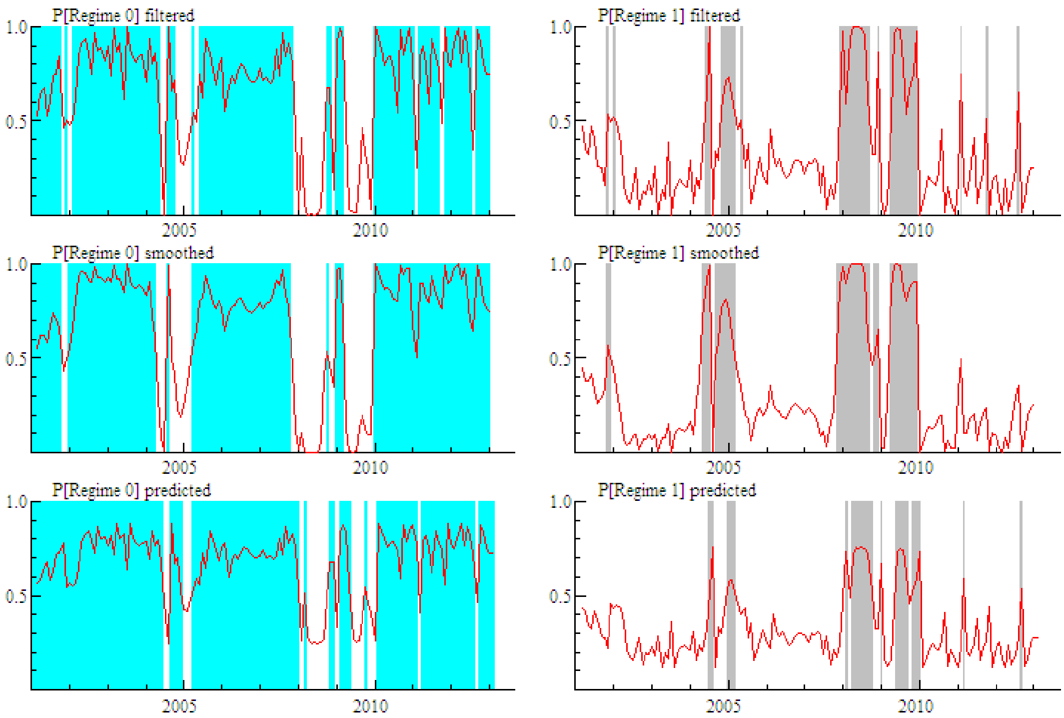

Figure 1. Filtered, smoothed and forecast probabilities for each state

The fitted conditional mean shown in Figure 2 appears to predict well the actual inflation series. This suggests that the Markov switching model has performed relatively well in tracking the inflation values for both the peaks and the troughs.

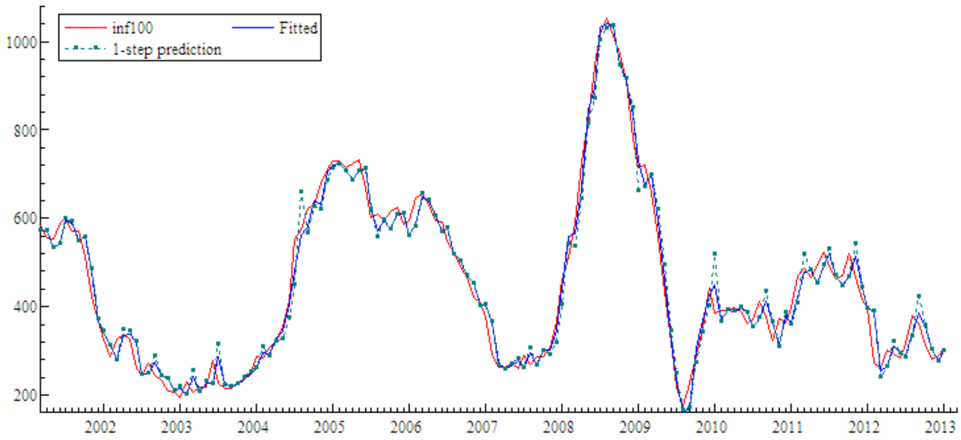

Figure 2. Actual Inflation vs. Conditional Mean

The results of the Markov-switching model may be used to classify the months into low inflation or high inflation periods depending on the probabilities (Table 5). Oxmetrics® uses smoothed probabilities in identifying the periods of low and high inflation.

Table 5. Dating of high and low inflation episodes based on the results of the Markov-switching model

Low Inflation	High Inflation
Jan 2002 - Apr 2004	May 2004 - Jul 2004
Apr 2005 - Oct 2007	Sep 2004 - Mar 2005
Oct 2008 - Oct 2008	Nov 2007 - Sep 2008
Jan 2009 - Mar 2009	Nov 2008 - Dec 2008
Jan 2010 - Dec 2012	Apr 2009 - Dec 2009

5.2. Logistic regression

The logistic regression model is considered in setting up an early warning system for high inflation in the Philippines. The probabilities resulting from the logit model could provide a fair assessment about the possible onset of inflation crisis in the Philippines. Based on the regime classification from the Markov-switching model, an episode of high inflation is tagged 1 while an episode of low inflation is labeled as 0. Model selection is done using the goodness of fit criterion AIC.

The results of the logistic regression model are shown in Tables 6. The signs of the coefficients of the crisis indicators are consistent with theoretical expectations. The world prices rice as well as equity prices and domestic liquidity are estimated to be positively associated with Philippine inflation. This implies that a surge in the values of these indicators increases the probability that the country will enter a high inflation regime. Meanwhile, the BSP's policy rate is found to be negatively associated with inflation, suggesting that adjustments in monetary policy settings are properly transmitted to the economy through the various transmission mechanisms. It may be noted that the other indicators are not included in the final model because their coefficients are insignificant or have theoretically-incorrect signs.

Table 6. Estimated Logit Model

Variable	Coefficient	Std. Error	z-statistic	Prob.
C	-2.964	0.499	-5.936	0.000
M3(-7)	1.032	0.422	2.443	0.015
POLICYRATE(-4)	-6.773	2.540	-2.667	0.008
POLICYRATE(-5)	-5.317	3.172	-1.677	0.094

Variable	Coefficient	Std. Error	z-statistic	Prob.
POLICYRATE(-6)	-6.218	2.691	-2.311	0.021
PSE(-4)	9.878	4.833	2.044	0.041
IR(-1)	0.069	0.019	3.663	0.000
AIC	0.775			
LR statistic	59.364			
Prob(LR statistic)	0.000			

5.3. Evaluation of the performance of the logit-based EWS model

Logit models could provide probability estimates resulting in one of the following scenarios:

Table 7. Probabilities of correct and incorrect crisis prediction

	High inflation	Low inflation
Signal Issued	P(1,1) = Correct call of crisis [A]	P(1,0) = Type II error or wrong signal [B]
No Signal Issued	P(0,1)=1-P(1,1)= Type I error or Missing Signal [C]	P(0,0)=1-P(1,0)= Correct call of non-event [D]

In Table 7, Event A represents the occasion when the model indicates a crisis when a high inflation event indeed occurs. Event B refers an event when a signal issued by the model is not followed by the occurrence of high inflation, i.e., wrong signal. It is also possible that the model does not signal a crisis (low estimated probability) but a crisis in fact occurs, i.e., missing signal, (Event C). Finally, Event D indicates a situation in which the model does not predict a crisis and no crisis occurs. In this paper, a threshold value of 0.5 is used to indicate whether the probabilities can already be interpreted as crisis signals.

To assess the performance of the EWS model, we utilize various performance criteria as suggested in Kaminsky *et al.* (1998).

1. Percent of crisis correctly called (PCCC) : $\frac{A}{A+C}$
2. Percent of non-crisis correctly called (PNCCC) : $\frac{D}{B+D}$
3. Percent of observations correctly called (POCC): $\frac{A+D}{A+B+C+D}$
4. Adjusted noise-to-signal ratio (ANSR): $\frac{B}{B+D}\Big/\frac{A}{A+C}$
5. Probability of an event of high inflation given a signal (PRGS): $\frac{A}{A+B}$
6. Probability of an event of high inflation given no signal (PRGNS): $\frac{C}{C+D}$
7. Percent of false alarms to total alarms (PFA): $\frac{B}{A+B}$

Results shown in Table 8 suggest that the model has some potential as an EWS tool. Based on the in-sample forecasts, the model is able to correctly predict 50 percent of high inflation and 95 percent of low inflation events. Overall, 83 percent of observations are correctly predicted by the model.

Moreover, the probability of a high inflation event given a signal is relatively high at 76 percent while the proportion of false alarms is relatively low at 24 percent.

An acceptable performance of a model within the sample does not imply good performance out of sample. In the evaluation of the out-of-sample forecasts, the EWS model is re-estimated using the sample period 2002-2007. The interest is to forecast the inflation regimes in 2008 and 2009 during and in the aftermath of the global commodity crisis. It may be noted that the forecast period is limited to 24 months in consideration of the policy horizon of the BSP as well as of the general forecast limitations of econometric models. Results in Tables 9 show that the probability of an event of high inflation given a signal stands at 79 percent, even higher than the in-sample equivalent of 76 percent. In addition, the proportion of false alarms for the out-of sample forecasts falls to 21 percent from 24 percent in the in-sample forecasts.

Table 8. Forecasts of the EWS model*

In-Sample		ACTUAL				
		High Inflation		Low Inflation		Total
PREDICTED	High Inflation	16	(50.0%)	5		21
	Low Inflation	16		88	(94.6%)	104
	Total	32		93		125
Out-of-Sample		ACTUAL				
		High Inflation		Low Inflation		Total
PREDICTED	High Inflation	11	(55.0%)	3		14
	Low Inflation	9		1	(25.0%)	10
	Total	20		4		24

*The first set of numbers represents counts while figures in parentheses represent percentages of correctly-predicted observations with respect to the two inflation regimes.

Table 9. Forecasting Performance of the EWS model

	In-Sample	**Out-of-Sample**
PCCC	50.0	55.0
PNCCC	94.6	25.0
POCC	83.2	50.0
ANSR	10.8	136.4
PRGS	76.2	78.6
PRGNS	15.4	90.0
PFA	23.8	21.4

The previous analysis is based on the choice of a threshold value of 0.5 to indicate whether the probabilities can already be interpreted as crisis signals. Bussiere and Fratzscher (2002) note that the lower the chosen threshold is, the more signals the model will send, but having the drawback of also raising the number of wrong signals (Type II errors). Meanwhile, increasing the threshold level reduces the number of wrong signals, at the expense of raising the number of missing crisis signals, that is, the absence of a signal when a crisis actually occurred (Type I errors). They add that from a policymakers' point of view, Type II errors may be less worrisome because they tend to be less costly from a welfare perspective than Type I errors. For these reasons, it may be prudent to consider a threshold value which is less than 0.5, in line with the policy bias put forth by Bussiere and Fratzscher (2002). In this paper, we use an alternative threshold value of 0.3 in evaluating the performance of the model.

Results that are shown in Table 10 point to an improvement in the in-sample forecasting performance of the model. Based on the in-sample results, the proportion of high inflation episodes correctly predicted by the model rises to 75 percent from 50 percent as a result of the lowering of the threshold. However, there appears to be some trade-offs in the use of the lower threshold with respect to out-of-sample forecasts. The probability of a high inflation event given a signal remains relatively high at 73 percent but lower compared to 79 percent which was recorded when the threshold value of 0.5 is used. In addition, the proportion of false alarms for the out-of sample forecasts rose slightly to 27 percent from 21 percent.

Table 10. Forecasting Performance of the EWS model

	In-Sample Threshold value		Out of Sample Threshold value	
	0.5	0.3	0.5	0.3
PCCC	50.0	75.0	55.0	55.0
PNCCC	94.6	89.2	25.0	0.0
POCC	83.2	85.6	50.0	45.8
ANSR	10.8	14.3	136.4	181.8
PRGS	76.2	70.6	78.6	73.3
PRGNS	15.4	8.8	90.0	100.0
PFA	23.8	29.4	21.4	26.7

5.4. Marginal effects

To help in quantifying the possibility of the occurrence of an incidence of high inflation, we also compute for the marginal effects of the explanatory variables. The direction of the effect of a change in X_j depends on the sign of the coefficient β_j, i.e., positive values of β_j imply that increasing X_j would increase the probability of the response. However, unlike the typical regression models where the dependent variable is continuous, the estimated coefficients cannot be interpreted as marginal effects on the binary dependent variable. Some researchers use the average of all the values of the explanatory variables as the representative values to estimate the marginal effects. However, Bartus (2005) argues that marginal effects computed at means are not good approximations of average marginal effects. He recommends the estimation of the average marginal effect which is the average of each observation's marginal effect. The average marginal effect may be more realistic in that it evaluates all observations and not just those at the means which can be biased approximations.

Results shown in Table 11 imply that a one-percentage-point increase in the price inflation of the benchmark rice 1 month ago increases the probability that the country will be in a high inflation state by 0.7 percentage point. A one-percent increase in the value of the stock index 4 months ago and in domestic liquidity (relative to trend) seven months ago raises the probability of a high inflation episode by about 1.0 percentage point and 0.1 percentage point, respectively. Meanwhile, the BSP's policy rate seems to have persistent effects on domestic inflation as suggested by the significance of lags 4, 5 and 6 in the model. In the case of the longer lag, a one-percentage-point increase in the BSP's RRP rate six months ago decreases the probability that the country will be in a high inflation state by about 63.5 percentage points. This result points to the potency of policy rate adjustments by the BSP to manage inflation.

Table 11. Marginal effects

Variables	Marginal Effects
M3(-7)	0.105
POLICYRATE(-4)	-0.692

POLICYRATE(-5)	-0.543
POLICYRATE(-6)	-0.635
PSEI(-4)	1.009
IRICE(-1)	0.007

Conclusion

This paper attempts to develop an early warning system (EWS) model for predicting the occurrence of high inflation in the Philippines to complement the BSP's existing suite of inflation forecasting models. Episodes of high and low inflation were identified using a Markov-switching model. Using the outcomes of the regime classification, a logistic regression model is then estimated with the objective of quantifying the possibility of the occurrence of high inflation episodes.

Results show that Philippine inflation may be modeled by a two-state MS-AR(2), with the estimated average inflation rate for the high inflation regime exceeding the upper bound of the current inflation target range of the BSP. The empirical results also suggest that it is more likely for the country to be in a state of low inflation than in a state of high inflation at least under the inflation targeting framework of the BSP. In addition, the estimated duration of low inflation is more than twice that of high inflation. Overall, the results of the Markov-switching model lend support to the effectiveness of the BSP's monetary policy instruments in managing inflation in the Philippines.

Meanwhile, results from the logistic regression model show that the indicators which are significantly related to domestic inflation include world prices of rice as well as equity prices and domestic liquidity. The policy rate of the BSP turns out to be significant as well, supporting the earlier results on the effectiveness of the BSP in steering inflation back to the target. Empirical results suggest that the EWS model has some potential as a complementary tool in the BSP's monetary policy formulation based on the in-sample and out-of sample forecasting performance.

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THE PHILLIPS CURVE AND A MICRO-FOUNDATION OF TREND INFLATION

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Abstract:

The hybrid New Keynesian Phillips curve has been criticized for lacking a micro-foundation. In this paper, an alternative purely forward-looking model of the Phillips curve is constructed on the basis of a micro-foundation of trend inflation. In addition, another source of output gaps other than frictions—a Nash equilibrium of a Pareto inefficient path—is considered. The model indicates that the role of frictions has been overestimated and that frictions are less important than previously have been thought. The conventional monetary policy of utilizing frictions cannot necessarily stabilize inflation. In contrast, the monetary policy of controlling the government's preference is very effective. A problem is that the effects of both types of monetary policy are not distinguishable.

Keywords: trend inflation, inflation persistence, central bank independence, the New Keynesian Phillips curve, the fiscal theory of the price level.

JEL Classification: E31, E58, E63.

1. Introduction

The pure New Keynesian Phillips curve (NKPC) has been criticized for possessing the serious problem that it is not consistent with the observed highly persistent nature of inflation (e.g., Fuhrer and Moore, 1995; Galí and Gertler, 1999). Mankiw (2001) argues that the NKPC is ultimately a failure and is not consistent with standard stylized facts about the dynamic effects of monetary policy. Since the work of Galí and Gertler (1999), a modified version of the NKPC—that is, a hybrid NKPC that includes lagged inflation—has been intensely studied. The hybrid NKPC well captures the persistent nature of inflation, but it remains puzzling why rational agents would behave in backward-looking manners, even if only partially so. Galí *et al.* (2005) argue that an important unresolved issue is the provision of a more coherent rationale for the role of lagged inflation in the hybrid NKPC. Furthermore, Fuhrer (2006) concluded that inflation in the hybrid NKPC inherits relatively little persistence from the driving process and that a micro-founded mechanism that generates substantial intrinsic persistence in inflation is required.

Recently, an alternative approach has been presented that argues that high intrinsic inflation persistence is spurious as a result of trend inflation. Cogley and Sbordone (2005, 2006) show that, if trend inflation is incorporated into the pure NKPC, its performance on fitting actual inflation data improves greatly. They conclude that trend inflation has been historically quite volatile and that, if these fluctuations of long-run moving trend inflation are taken into account, a purely forward-looking model approximates the short-run dynamics of inflation quite well. Woodford (2007) considers that Cogley and Sbordone (2005) present an alternative interpretation of the apparent need for lagged inflation terms in the NKPC (see also Hornstein, 2007). Indeed, data on inflation in most industrial economies show high levels of volatility and a transition from high inflation to low inflation in the 1980s, which strongly implies the existence of trends in inflation (e.g., Stock and Watson, 2006; Sbordone, 2007). Ascari (2004) argues that disregarding trend inflation is very far from being an innocuous assumption and that the results obtained by models log-linearized around a zero inflation steady state are misleading (see also Bakhshi *et al.*, 2003). These studies suggest that the puzzle of inflation persistence in the NKPC will be solved by incorporating trend inflation into the NKPC. However, if we proceed further in this research direction, another serious theoretical problem arises, that is, the lack of a micro-foundation of trend inflation. Can trend inflation be explained as a consequence of rational agents' optimizations? Why do monetary policymakers often allow upward trends in inflation? This paper presents a micro-foundation of trend inflation.

The fiscal theory of the price level (FTPL) argues that a problem with conventional inflation theory is that it largely neglects the importance of the government's borrowing behavior in inflation dynamics (e.g., Leeper, 1991; Sims, 1994, 1998, 2001; Woodford, 1995, 2001; Cochrane, 1998a, 1998b, 2005). The FTPL implies that, if a government's borrowing behavior is well modeled, the mechanism of severely deviated inflation paths can be explained without assuming ad hoc frictions or irrationality. In this paper, this possibility is explored and a model of trend inflation that is firmly based on a micro-foundation is constructed (see Harashima, 2008b). The model indicates that trend inflation accelerates or decelerates if the time preference rates of the government and the representative household are heterogeneous.

Another important factor in the Phillips curve that should also be carefully examined is the nature of output gaps. In the NKPC, output gaps are assumed to be generated only by frictions. Without frictions, no output gaps can exist because, if an economy is under full price flexibility, its equilibrium output level is always sustained. However, this New Keynesian explanation has not generally been regarded as sufficiently successful, because price rigidity has been criticized for its fragile theoretical (micro-) foundation and its inability to explain the persistent nature of inflation. As shown above, Mankiw (2001) severely criticized the NKPC. This criticism implies that there will be other sources of output gaps. In this paper, I consider another source of output gaps that are generated even under full price flexibility (see Harashima, 2012, 2013a, 2013b). Rational agents will usually not allow Pareto inefficiency (e.g., output gaps) to remain for a long period; it will disappear soon after it is generated under full price flexibility. However, an exception is possible because Nash equilibrium can conceptually coexist with Pareto inefficiency. If a Nash equilibrium that consists of strategies that generate Pareto inefficient payoffs is rationally selected, rigidity-like phenomena may be observed. This paper shows that a Nash equilibrium consisting of strategies of choosing a Pareto inefficient transition path of consumption to the steady state (hereafter called a "Nash equilibrium of a Pareto inefficient path") is generated even in a frictionless economy if - and probably only if - the rate of time preference shifts. An essential reason for the generation of this path is that households are intrinsically risk averse and not cooperative. In a strategic environment, this generates the possibility that, if consumption needs to be substantially and discontinuously increased to keep Pareto optimality, a non-cooperative household's strategy to deviate from the Pareto optimal path gives a higher expected utility than the strategy of choosing the Pareto optimal path.

The above-mentioned two factors (a model of trend inflation and a mechanism of output gaps under full price flexibility) are considered in analyzes of monetary policies, and an alternative model of the Phillips curve is constructed. In contrast to the NKPC, both factors are fully based on micro-foundations. Comparisons between this new model and the NKPC indicate that the role of frictions has been overestimated and that frictions are less important than has been thought.

The paper is organized as follows. In Section 2, I construct a model of trend inflation that assumes an economically Leviathan government, in which the government and the representative household behave in purely forward-looking manners and achieve simultaneous optimization. Section 3 shows that Nash equilibrium of a Pareto inefficient path is rationally generated when the time preference rates of risk-averse and non-cooperative households shift. In Section 4, a new model of the Phillips curve is constructed and compared with the NKPC. Finally, I offer concluding remarks in Section 5.

2. Trend inflation

2.1. The model of trend inflation[19]

2.1.1. The government

2.1.1.1. The government budget constraint

The government budget constraint is:

$$\dot{B}_t = B_t i_t + G_t - X_t - \vartheta_t ,$$

where B_t is the nominal obligation of the government to pay for its accumulated bonds, i_t is the nominal interest rate for government bonds, G_t is the nominal government expenditure, X_t is the nominal tax revenue, and ϑ_t is the nominal amount of seigniorage at time *t*. The tax is assumed to be lump sum, the government bonds are long term, and the returns on the bonds are realized only after the bonds are held during a unit period (e.g., a year). The government bonds are redeemed in a unit period, and the government successively refinances the bonds by issuing new ones at each time *t*.

Let $b_t = \frac{B_t}{P_t}$, $g_t = \frac{G_t}{P_t}$, $x_t = \frac{X_t}{P_t}$, and $\varphi_t = \frac{\vartheta_t}{P_t}$, where P_t is the price level at time *t*.

Let also $\pi_t = \frac{\dot{P}_t}{P_t}$ be the inflation rate at time *t*. By dividing by P_t, the budget constraint is transformed to $\frac{\dot{B}_t}{P_t} = b_t i_t + g_t - x_t - \varphi_t$, which is equivalent to:

$$\dot{b}_t = b_t i_t + g_t - x_t - \varphi_t - b_t \pi_t = b_t (i_t - \pi_t) + g_t - x_t - \varphi_t \quad (1)$$

Because the returns on government bonds are realized only after holding the bonds during a unit period, investors buy the bonds if $\bar{i}_t \geq E_t \int_t^{t+1} (\pi_s + r_s) ds$ at time *t*, where $\bar{i}_t$ is the nominal interest rate for bonds bought at *t* and r_t is the real interest rate in markets at *t*. Hence, by arbitrage, $\bar{i}_t = E_t \int_t^{t+1} (\pi_s + r_s) ds$ and if r_t is constant such that $r_t = r$ (i.e., if it is at steady state), then:

$$\bar{i}_t = E_t \int_t^{t+1} \pi_s \, ds + r$$

The nominal interest rate $\bar{i}_t = E_t \int_t^{t+1} \pi_s \, ds + r$ means that, during a sufficiently small period between *t* and *t* + *dt*, the government's obligation to pay for the bonds' return in the future increases not by $dt(\pi_t + r)$ but by $dt\left(E_t \int_t^{t+1} \pi_s \, ds + r \right)$.

If π_t is constant, then $E_t \int_t^{t+1} \pi_s \, ds = \pi_t$ and $\bar{i}_t = \pi_t + r$, but if π_t is not constant, these equations do not necessarily hold.

[19] The model of the optimal trend inflation in this paper is based on the inflation model in Harashima (2007). Harashima (2004b, 2008a, 2013a) are also related to the model and analyses in this paper.

Since bonds are redeemed in a unit period and successively refinanced, the bonds the government is holding at *t* have been issued between *t* - 1 and *t*. Hence, under perfect foresight, the average nominal interest rate for all government bonds at time *t* is the weighted sum of $\bar{i}_t$ such that

$$i_t = \int_{t-1}^{t} \bar{i}_s \left(\frac{\overline{B}_{s,t}}{\int_{t-1}^{t} \overline{B}_{v,t}\ dv} \right) ds = \int_{t-1}^{t} \int_{s}^{s+1} \pi_v\ dv \left(\frac{\overline{B}_{s,t}}{\int_{t-1}^{t} \overline{B}_{v,t}\ dv} \right) ds + r$$

where $\overline{B}_{s,t}$ is the nominal value of bonds at time *t* that were issued at time *s*. If the weights $\frac{\overline{B}_{s,t}}{\int_{t-1}^{t} \overline{B}_{v,t}\ dv}$ between *t* - 1 and *t* are not so different from each other, then approximately $i_t = \int_{t-1}^{t} \int_{s}^{s+1} \pi_\upsilon\, d\upsilon\, ds + r$. To be precise, if the absolute values of π_s for $t-1 < s \leq t+1$ are sufficiently smaller than unity, the differences among the weights are negligible and then approximately

$$i_t = \int_{t-1}^{t} \int_{s}^{s+1} \pi_\upsilon\, d\upsilon\, ds + r \tag{2}$$

(see Harashima, 2008). The average nominal interest rate for the total government bonds, therefore, develops by $i_t = \int_{t-1}^{t} \int_{s}^{s+1} \pi_\upsilon\, d\upsilon\, ds + r$. If π_t is constant, then $\int_{t-1}^{t} \int_{s}^{s+1} \pi_\upsilon\, d\upsilon\, ds = \pi_t$; thus, $i_t = \pi_t + r$. If π_t is not constant, however, the equations $\int_{t-1}^{t} \int_{s}^{s+1} \pi_\upsilon\, d\upsilon\, ds = \pi_t$ and $i_t = \pi_t + r$ do not necessarily hold.

2.1.1.2. An economically Leviathan government

Under a proportional representation system, the government represents the median household whereas the representative household from an economic perspective represents the mean household.[20] Because of this difference, they usually have different preferences. To account for this essential difference, a Leviathan government is assumed in the model.[21] There are two extremely different views regarding government's behavior in the literature on political economy: the Leviathan view and the benevolent view (e.g., Downs 1957; Brennan and Buchanan 1980; Alesina and Cukierman 1990). From an economic point of view, a benevolent government maximizes the expected economic utility of the representative household, but a Leviathan government does not. Whereas the expenditure of a benevolent government is a tool used to maximize the economic utility of the representative household, the expenditure of a Leviathan government is a tool used to achieve the government's own policy objectives.[22] For example, if a Leviathan government considers national security to be the most important political issue, defense spending will increase greatly, but if improving social welfare is the top political priority, spending on social welfare will increase dramatically, even though the increased expenditures may not necessarily increase the economic utility of the representative household.

Is it possible, however, for such a Leviathan government to hold office for a long period? Yes, because a government is generally chosen by the median of households under a proportional

[20] See the literature on the median voter theorem (e.g., Downs 1957). Also see the literature on the delay in reforms (e.g., Alesina and Drazen 1991).

[21] The most prominent reference to Leviathan governments is Brennan and Buchanan (1980).

[22] The government's behavior assumed in the fiscal theory of the price level reflects an aspect of a Leviathan government. Christiano and Fitzgerald (2000) argue that non-Ricardian policies correspond to the type of policies in which governments are viewed as selecting policies and committing themselves to those policies in advance of prices being determined in markets.

representation system (e.g., Downs 1957), whereas the representative household usually presumed in the economics literature is the mean household. The economically representative household is not usually identical to the politically representative household, and a majority of people could support a Leviathan government even if they know that the government does not necessarily pursue only the economic objectives of the economically representative household. In other words, the Leviathan government argued here is an economically Leviathan government that maximizes the political utility of people, whereas the conventional economically benevolent government maximizes the economic utility of people. In addition, because the politically and economically representative households are different (the median and mean households, respectively), the preferences of future governments will also be similarly different from those of the mean representative household. In this sense, the current and future governments presented in the model can be seen as a combined government that goes on indefinitely; that is, the economically Leviathan government always represents the median representative household.

The Leviathan view generally requires the explicit inclusion of government expenditure, tax revenue, or related activities in the government's political utility function (e.g., Edwards and Keen 1996). Because an economically Leviathan government derives political utility from expenditure for its political purposes, the larger the expenditure is, the happier the Leviathan government will be. But raising tax rates will provoke people's antipathy, which increases the probability of being replaced by the opposing party that also nearly represents the median household. Thus, the economically Leviathan government regards taxes as necessary costs to obtain freedom of expenditure for its own purposes. The government therefore will derive utility from expenditure and disutility from taxes. Expenditure and taxes in the political utility function of the government are analogous to consumption and labor hours in the economic utility function of the representative household. Consumption and labor hours are both control variables, and as such, the government's expenditure and tax revenue are also control variables. As a whole, the political utility function of economically Leviathan government can be expressed as $u_G(g_t, x_t)$.[23]

In addition, it can be assumed on the basis of previously mentioned arguments that $\frac{\partial u_G}{\partial g_t} > 0$ and $\frac{\partial^2 u_G}{\partial {g_t}^2} < 0$, and therefore that $\frac{\partial u_G}{\partial x_t} < 0$ and $\frac{\partial^2 u_G}{\partial {x_t}^2} > 0$.[24] An economically Leviathan government therefore maximizes the expected sum of these utilities discounted by its time preference rate under the constraint of deficit financing.

2.1.1.3. The optimization problem

The optimization problem of an economically Leviathan government is:

$$Max\ E\int_0^{\infty} u_G(g_t, x_t)\exp(-\theta_G\, t)dt$$

[23] It is possible to assume that governments are partially benevolent. In this case, the utility function of a government can be assumed to be $u_G(g_t, x_t, c_t, l_t)$, where c_t is real consumption and l_t is the leisure hours of the representative household. However, if a lump-sum tax is imposed, the government's policies do not affect steady-state consumption and leisure hours. In this case, the utility function can be assumed to be $u_G(g_t, x_t)$.

[24] Some may argue that it is more likely that $\frac{\partial u_G}{\partial x_t} > 0$ and $\frac{\partial^2 u_G}{\partial {x_t}^2} < 0$. However, the assumption used is not an important issue here because $-x_t\left[\frac{\partial u_G(g_t, x_t)}{\partial x_t}\right]^{-1}\frac{\partial^2 u_G(g_t, x_t)}{\partial {x_t}^2}\frac{\dot{x}_t}{x_t} = 0$ at steady state, as will be shown in the solution to the optimization problem later in the paper. Thus, the results are not affected by which assumption is used.

subject to the budget constraint:

$$\dot{b}_t = b_t(i_t - \pi_t) + g_t - x_t - \varphi_t \, , \tag{3}$$

where u_G is the constant relative risk aversion utility function of the government, θ_G is the government's rate of time preference, and E is the expectation operator. All variables are expressed in per capita terms, and population is assumed to be constant. The government maximizes its expected political utility considering the behavior of the economically representative household that is reflected in i_t in its budget constraint.

2.1.2. Households

The economically representative household maximizes its expected economic utility. Sidrauski (1967)'s well-known money in the utility function model is used for the optimization problem. The representative household maximizes its expected utility:

$$E\int_0^\infty u_P(c_t, m_t)\exp(-\theta_P t)dt$$

subject to the budget constraint:

$$\dot{a}_t = (r_t a_t + w_t + \sigma_t) - [c_t + (\pi_t + r_t)m_t] - g_t \, ,$$

where u_P and θ_P are the utility function and the time preference rate of the representative household, c_t is real consumption, w_t is real wage, σ_t is lump-sum real government transfers, m_t is real money, $a_t = k_t + m_t$, and k_t is real capital. It is assumed that $r_t = f'(k_t)$, $w_t = f(k_t) - k_t f'(k_t)$, $u_P' > 0$, $u_P'' < 0$, $\frac{\partial u_P(c_t, m_t)}{\partial m_t} > 0$, and $\frac{\partial^2 u_P(c_t, m_t)}{\partial m_t^2} < 0$, *where* $f(\cdot)$ is the production function. Government expenditure (g_t) is an exogenous variable for the representative household because it is an economically Leviathan government. It is also assumed that, although all households receive transfers from a government in equilibrium, when making decisions, each household takes the amount it receives as given, independent of its money holdings. Thus, the budget constraint means that the real output $f(k_t)$ at any time is demanded for the real consumption c_t, the real investment $\dot{k}_t$, and the real government expenditure g_t such that $f(k_t) = c_t + \dot{k}_t + g_t$. The representative household maximizes its expected economic utility considering the behavior of government reflected in g_t in the budget constraint. In this discussion, a central bank is not assumed to be independent of the government; thus, the functions of the government and the central bank are not separated. This assumption can be relaxed, and the roles of the government and the central bank are explicitly separated in Section 2.2.

Note that the time preference rate of government (θ_G) is not necessarily identical to that of the representative household (θ_P) because the government and the representative household represent different households (i.e., the median and mean households, respectively). In addition, the preferences will differ because (1) even though people want to choose a government that has the same time preference rate as the representative household, the rates may differ owing to errors in expectations (e.g., Alesina and Cukierman 1990); and (2) current voters cannot bind the choices of future voters and, if current voters are aware of this possibility, they may vote more myopically as compared with their own rates of impatience in private economic activities (e.g., Tabellini and Alesina 1990). Hence, it is highly likely that the time preference rates of a government and the representative household are heterogeneous. It should be also noted, however, that even though the rates of time preference are heterogeneous, an economically Leviathan government behaves based only on its own time preference rate, without hesitation.

2.1.3. The simultaneous optimization

First, I examine the optimization problem of the representative household. Let Hamiltonian H_P be:

$$H_P = u_P(c_t, m_t)\exp(-\theta_P t) + \lambda_{P,t}[r_t a_t + w_t + \sigma_t - c_t - (\pi_t + r_t)m_t - g_t],$$

where $\lambda_{P,t}$ is a costate variable, c_t and m_t are control variables, and a_t is a state variable. The optimality conditions for the representative household are:

$$\frac{\partial u_P(c_t, m_t)}{\partial c_t}\exp(-\theta_P t) = \lambda_{P,t}, \tag{4}$$

$$\frac{\partial u_P(c_t, m_t)}{\partial m_t}\exp(-\theta_P t) = \lambda_{P,t}(\pi_t + r_t), \tag{5}$$

$$\dot{\lambda}_{P,t} = -\lambda_{P,t} r_t, \tag{6}$$

$$\dot{a}_t = (r a_t + w_t + \sigma_t) - [c_t + (\pi_t + r_t)m_t - g_t], \tag{7}$$

$$\lim_{t\to\infty} \lambda_{P,t} a_t = 0. \tag{8}$$

By conditions (4) and (5), $\left[\frac{\partial u_P(c_t, m_t)}{\partial c_t}\right]^{-1} \frac{\partial u_P(c_t, m_t)}{\partial m_t} = \pi_t + r_t$, and by conditions (4) and (6),

$$-c_t\left[\frac{\partial u_P(c_t, m_t)}{\partial c_t}\right]^{-1} \frac{\partial^2 u_P(c_t, m_t)}{\partial c_t^2}\frac{\dot{c}_t}{c_t} + \theta_P = r_t. \tag{9}$$

Hence,

$$\theta_P = r_t = r \tag{10}$$

at steady state such that $\dot{c}_t = 0$ and $\dot{k}_t = 0$.

Next, I examine the optimization problem of the economically Leviathan government. Let Hamiltonian H_G be $H_G = u_G(g_t, x_t)\exp(-\theta_G t) + \lambda_{G,t}[b_t(i_t - \pi_t) + g_t - x_t - \varphi_t]$, where $\lambda_{G,t}$ is a costate variable. The optimality conditions for the government are:

$$\frac{\partial u_G(g_t, x_t)}{\partial g_t}\exp(-\theta_G t) = -\lambda_{G,t}, \tag{11}$$

$$\frac{\partial u_G(g_t, x_t)}{\partial x_t}\exp(-\theta_G t) = \lambda_{G,t}, \tag{12}$$

$$\dot{\lambda}_{G,t} = -\lambda_{G,t}(i_t - \pi_t), \tag{13}$$

$$\dot{b}_t = b_t(i_t - \pi_t) + g_t - x_t - \varphi_t, \tag{14}$$

$$\lim_{t\to\infty} \lambda_{G,t} b_t = 0. \tag{15}$$

Combining conditions (11), (12), and (13) and Eq. (2) yields the following equations:

$$-g_t\left[\frac{\partial u_G(g_t,x_t)}{\partial g_t}\right]^{-1}\frac{\partial^2 u_G(g_t,x_t)}{\partial g_t^2}\frac{\dot{g}_t}{g_t}+\theta_G=i_t-\pi_t=r_t+\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\; ds-\pi_t \tag{16}$$

and

$$-x_t\left[\frac{\partial u_G(g_t,x_t)}{\partial x_t}\right]^{-1}\frac{\partial^2 u_G(g_t,x_t)}{\partial x_t^{\;2}}\frac{\dot{x}_t}{x_t}+\theta_G=i_t-\pi_t=r_t+\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\; ds-\pi_t\,. \tag{17}$$

Here, $g_t\left[\frac{\partial u_G(g_t,x_t)}{\partial g_t}\right]^{-1}\frac{\partial^2 u_G(g_t,x_t)}{\partial g_t^2}\frac{\dot{g}_t}{g_t}=0$ and $x_t\left[\frac{\partial u_G(g_t,x_t)}{\partial x_t}\right]^{-1}\frac{\partial^2 u_G(g_t,x_t)}{\partial x_t^{\;2}}\frac{\dot{x}_t}{x_t}=0$ at steady state such that $\dot{g}_t = 0$ and $\dot{x}_t = 0$; thus,

$$\theta_G=r_t+\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\, ds-\pi_t\,. \tag{18}$$

Hence, by Eq. (10),

$$\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\, ds=\pi_t+\theta_G-\theta_P \tag{19}$$

at steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$, and $\dot{k}_t = 0$.[25]

Equation (19) is a natural consequence of simultaneous optimization by the economically Leviathan government and the representative household. If the rates of time preference are heterogeneous between them, then:

$$i_t-r=\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\, ds\neq\pi_t\,.$$

This result might seem surprising because it has been naturally conjectured that $i_t = \pi_t + r$. However, this is a simple misunderstanding because π_t indicates the instantaneous rate of inflation at a point such that $\pi_t=\frac{\dot{P}_t}{P_t}$, whereas $\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\, ds$ roughly indicates the average inflation rate in a period. Equation (19) indicates that π_t develops according to the integral equation $\pi_t=\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\, ds-\theta_G+\theta_P$. If π_t is constant, the equations $i_t=\pi_t+r$ and $\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\, ds=\pi_t$ are true. However, if π_t is not constant, the equations do not necessarily hold. Equation (19) indicates that the equations $i_t=\pi_t+r$ and $\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon\, d\upsilon\, ds=\pi_t$ hold only in the case where $\theta_G = \theta_P$ (i.e., a homogeneous rate of time preference). It has been previously thought that a homogeneous rate of time preference naturally prevails; thus, the equation $i_t = \pi_t + r$ has not been questioned. As argued previously, however, a homogeneous rate of time preference is not usually guaranteed.

[25] If and only if $\theta_G=-\frac{g_t-x_t-\varphi_t}{b_t}$ at steady state, then the transversality condition (15) $\lim_{t\to\infty}\lambda_{G,t}\, b_t=0$ holds. The proof is shown in Harashima (2008b).

2.1.4. The law of motion for trend inflation

Equation (19) indicates that inflation accelerates or decelerates as a result of the government and the representative household reconciling the contradiction in heterogeneous rates of time preference. If π_t is constant, the equation $\pi_t = \int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon \, d\upsilon \, ds$ holds; conversely, if $\pi_t \neq \int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon \, d\upsilon \, ds$, then π_t is not constant. Without the acceleration or deceleration of inflation, therefore, Eq. (19) cannot hold in an economy in which $\theta_G \neq \theta_P$. In other words, it is not until $\theta_G \neq \theta_P$ that inflation can accelerate or decelerate. Heterogeneous time preferences ($\theta_G \neq \theta_P$) bend the path of inflation and enables inflation to accelerate or decelerate. The difference of time preference rates ($\theta_G - \theta_P$) at each time needs to be transformed to the accelerated or decelerated inflation rate π_t at each time.

Equation (19) implies that inflation accelerates or decelerates nonlinearly in the case in which $\theta_G \neq \theta_P$. For a sufficiently small period dt, π_{t+1+dt} is determined with π_s $(t-1<s\leq t+1)$ that satisfies $\int_{t-1}^{t}\int_{s}^{s+1}\pi_\upsilon \, d\upsilon \, ds - \pi_t = \theta_G - \theta_P$, so as to hold the equation $\int_{t}^{t+dt}\int_{s}^{s+1}\pi_\upsilon \, d\upsilon \, ds$ $= \int_{t-1}^{t-1+dt}\int_{s}^{s+1}\pi_\upsilon \, d\upsilon \, ds + \pi_{t+dt} - \pi_t$. A solution of the integral Eq. (19) for given θ_G and θ_P is:

$$\pi_t = \pi_0 + 6(\theta_G - \theta_P)t^2. \tag{20}$$

Generally, the path of inflation that satisfies Eq. (19) for $0 \leq t$ is expressed as:

$$\pi_t = \pi_0 + 6(\theta_G - \theta_P)\exp[z_t \ln(t)], \tag{21}$$

where z_t is a time dependent variable. The stream of z_t is various depending on the boundary condition, i.e., the past and present inflation during $-1<t\leq 0$ and the path of inflation during $0<t\leq 1$ that is set to make π_0 satisfy Eq. (19). However, z_t has the following important property. If π_t satisfies Eq. (19) for $0 \leq t$, and $-\infty < \pi_t < \infty$ for $-1<t\leq 1$, then:

$$\lim_{t\to\infty} z_t = 2.$$

Proof is shown in Harashima (2008b). Any inflation path that satisfies Eq. (19) for $0 \leq t$ therefore asymptotically approaches the path of Eq. (20). The mechanism behind the law of motion for inflation (Eq. [20]) is examined more in detail in Harashima (2008b).

2.1.5. The optimal trend inflation

The trend inflation should be consistent with Eq. (21). The discrete-time version of Eq. (21) is

$$\pi_t^T = \pi_\varphi^T + 6(\theta_G - \theta_P)\exp[z_t \ln(t-\varpi)] \tag{22}$$

and equivalently

$$\pi_{t+1}^T = \pi_t^T + 6(\theta_G - \theta_P)\{\exp[z_{t+1}\ln(t-\varpi+1)] - \exp[z_t \ln(t-\varpi)]\} \tag{23}$$

where π_t^T is the trend component in inflation in period *t*, and ϖ $(\leq t)$ is the period when the latest shock on θ_G occurred. It will be explained later in Section 2.2 that θ_G should be time-variable and shocks on θ_G play an important role in inflation dynamics. When a shock on θ_G occurs and the value of θ_G is changed in period ϖ, the trend inflation need be adjusted to be consistent with the new value of θ_G for the new initial period ϖ. The value of z_t is determined by the mechanism explained in Section 2.1.2. Equations (22) and (23) are used in the model as the trend component in inflation.

2.2. The central bank

In Section 2.1, central banks are not explicitly considered because they are not assumed to be independent of governments. However, in actuality, central banks are independent organizations in most countries even though some of them are not sufficiently independent. Furthermore, in the conventional inflation model, it is the central banks that control inflation and governments have no role in controlling inflation. Conventional inflation models show that the rate of inflation basically converges at the target rate of inflation set by a central bank. The target rate of inflation therefore is the key exogenous variable that determines the path of inflation in these models.

Both the government and the central bank can probably affect the development of inflation, but they would do so in different manners, as Eq. (21) and conventional inflation models indicate. However, the objectives of the government and the central bank may not be the same. For example, if trend inflation is added to conventional models by replacing their aggregate supply equations with Eq. (21), inflation cannot necessarily converge at the target rate of inflation because another key exogenous variable (θ_G) is included in the models. A government makes inflation develop consistently with the Eq. (21), which implies that inflation will not necessarily converge at the target rate of inflation. Conversely, a central bank makes inflation converge at the target rate of inflation, which implies that inflation will not necessarily develop consistently with Eq. (21). That is, unless either θ_G is adjusted to be consistent with the target rate of inflation or the target rate of inflation is adjusted to be consistent with θ_G, the path of inflation cannot necessarily be determined. Either θ_G or the target rate of inflation need be an endogenous variable. If a central bank dominates, the target rate of inflation remains as the key exogenous variable and θ_G should then be an endogenous variable. The reverse is also true.

A central bank will be regarded as truly independent if θ_G is forced to be adjusted to the one that is consistent with the target rate of inflation set by the central bank. For example, suppose that $\theta_G > \theta_P$ and a truly independent central bank manipulates the nominal interest rate. Here,

$$i_t = \int_{t-1}^{t} \int_{s}^{s+1} \pi_v \, dv \, ds + r = \theta_G + \pi_t \tag{24}$$

at steady state such that $\dot{g}_t = 0$, $\dot{x}_t = 0$, $\dot{c}_t = 0$, and $\dot{k}_t = 0$ by Eqs. (1), (7), and (13). If the accelerating inflation rate is higher than the target rate of inflation, the central bank can raise the nominal interest rate from $i_t = \theta_G + \pi_t$ (Eq. [24]) to

$$i_t = \theta_G + \pi_t + \psi$$

by positive ψ by intervening in financial markets to lower the accelerating rate of inflation. In this case, the central bank keeps the initial target rate of inflation because it is truly independent. The government thus faces a rate of increase of real obligation that is higher than θ_G by the extra rate ψ.[26] If the government lowers θ_G so that $\theta_G < \theta_P$ and inflation stops accelerating, the central bank will accordingly reduce the extra rate ψ. If, however, the government does not accommodate θ_G to the target rate of inflation, the extra rate ψ will increase as time passes because of the gap between the accelerating

[26] The extra rate ψ affects not only the behavior of government but also that of the representative household, in which the conventional inflation theory is particularly interested. In this sense, the central bank's instrument rule that concerns and simultaneously affects both behaviors of the government and the representative household is particularly important for price stability.

inflation rate and the target rate of inflation widens. Because of the extra rate ψ, the government has no other way to achieve optimization unless it lowers θ_G to one that is consistent with the target rate of inflation. Once the government recognizes that the central bank is firmly determined to be independent and it is in vain to try to intervene in the central bank's decision makings, the government would not dare to attempt to raise θ_G again anymore.

Equation (22) implies that a government allows inflation to accelerate because it acts to maximize its expected utility based only on its own preferences. A government is hardly the only entity that cannot easily control its own preferences even when these preferences may result in unfavorable consequences. It may not even be possible to manipulate one's own preferences at will. Thus, even though a government is fully rational and is not weak, foolish, or untruthful, it is difficult for it to self-regulate its preferences. Hence, an independent neutral organization is needed to help control θ_G. Delegating the authority to set and keep the target rate of inflation to an independent central bank is a way to control θ_G. The delegated independent central bank will control θ_G because it is not the central bank's preference to stabilize the price level - it is simply a duty delegated to it. An independent central bank is not the only possible choice. For example, pegging the local currency with a foreign currency can be seen as a kind of delegation to an independent neutral organization. In addition, the gold standard that prevailed before World War II can be also seen as a type of such delegation.

Note also that the delegation may not be viewed as bad from the Leviathan government's point of view because only its rate of time preference is changed, and the government can still pursue its political objectives. One criticism of the argument that central banks should be independent (e.g., Blinder 1998) is that, since the time-inconsistency problem argued in Kydland and Prescott (1977) or Barro and Gordon (1983) is more acute with fiscal policy, why is it not also necessary to delegate fiscal policies?

An economically Leviathan government, however, will never allow fiscal policies to be delegated to an independent neutral organization because the Leviathan government would then not be able to pursue its political objectives, which in a sense would mean the death of the Leviathan government. The median household that backs the Leviathan government, but at the same time dislikes high inflation, will therefore support the delegation of authority but only if it concerns monetary policy. The independent central bank will then be given the authority to control θ_G and oblige the government to change θ_G in order to meet the target rate of inflation.

Without such a delegation of authority, it is likely that generally $\theta_G > \theta_P$ because θ_G represents the median household whereas θ_P represents the mean household. Empirical studies indicate that the rate of time preference negatively correlates with permanent income (e.g., Lawrance 1991), and the permanent income of the median household is usually lower than that of the mean household. If generally $\theta_G > \theta_P$, that suggests that inflation will tend to accelerate unless a central bank is independent. The independence of the central bank is therefore very important in keeping the path of inflation stable.

Note also that the forced adjustments of θ_G by an independent central bank are exogenous shocks to both the government and the representative household because they are planned solely by the central bank. When a shock on θ_G is given, the government and the representative household must recalculate their optimal paths including the path of inflation by resetting θ_G, π_t, and φ in Eq. (22).

3. Output gaps

3.1. Model with non-cooperative households [27]

This section examines another source of output gaps other than frictions. A Ramsey type growth model with non-cooperative households is constructed to examine economic fluctuations.

3.1.1. The shock

The model describes the utility maximization of households after an upward time preference shock. This shock was chosen because it is one of the few shocks that result in a Nash equilibrium of a Pareto inefficient path. Another important reason for selecting an upward time preference shock is that it shifts the steady state to lower levels of production and consumption than before the shock, which is consistent with the phenomena actually observed in a recession.

Although the rate of time preference is a deep parameter, it has not been regarded as a source of shocks for economic fluctuations, possibly because the rate of time preference is thought to be constant and not to shift suddenly. There is also a practical reason, however. Models with a permanently constant rate of time preference exhibit excellent tractability (see Samuelson, 1937). However, the rate of time preference has been naturally assumed and actually observed to be time-variable. The concept of a time-varying rate of time preference has a long history (e.g., Böhm-Bawerk, 1889; Fisher, 1930). More recently, Lawrance (1991) and Becker and Mulligan (1997) showed that people do not inherit permanently constant rates of time preference by nature and that economic and social factors affect the formation of time preference rates. Their arguments indicate that many incidents can affect and change the rate of time preference throughout a person's life. For example, Parkin (1988) examined business cycles in the United States, explicitly considering the time-variability of the time preference rate, and showed that the rate of time preference was as volatile as technology and leisure preference.

3.1.2. Households

Households are not intrinsically cooperative. Except in a strict communist economy, households do not coordinate themselves to behave as a single entity when consuming goods and services. The model in this paper assumes non-cooperative, identical, and infinitely long living households and that the number of households is sufficiently large. Each of them equally maximizes the expected utility:

$$E_0 \int_0^\infty \exp(-\theta t) u(c_t) dt \text{, subject to: } \frac{dk_t}{dt} = f(A, k_t) - \delta k_t - c_t \text{,}$$

where y_t, c_t, and k_t are production, consumption, and capital per capita in period t, respectively; A is technology and constant; u is the utility function; $y_t = f(A, k_t)$ is the production function; $\theta(>0)$ is the rate of time preference; δ is the rate of depreciation; and E_0 is the expectations operator conditioned on the agents' period 0 information set. y_t, c_t, and k_t are monotonously continuous and differentiable in t, and u and f are monotonously continuous functions of c_t and k_t, respectively. All households initially have an identical amount of financial assets equal to k_t, and all households gain the identical amount of income $y_t = f(A, k_t)$ in each period. It is assumed that $\frac{du(c_t)}{dc_t} > 0$ and $\frac{d^2 u(c_t)}{dc_t^2} < 0$; thus, households are risk averse. For simplicity, the utility function is specified to be the constant relative risk aversion utility function:

$$u(c_t) = \frac{c_t^{1-\gamma}}{1-\gamma} \text{ if } \gamma \neq 1$$

$$u(c_t) = \ln(c_t) \text{ if } \gamma = 1,$$

[27] The model in Section 3 is based on the model by Harashima (2012). See also Harashima (2004a, 2013b, 2013c).

where γ is a constant and $0 < \gamma < \infty$. In addition, $\frac{\partial f(A, k_t)}{\partial k_t} > 0$ and $\frac{\partial^2 f(k_t)}{\partial k_t^2} < 0$. Both technology (*A*) and labor supply are assumed to be constant.

The effects of an upward shift in time preference are shown in Figure 1. Suppose first that the economy is at steady state before the shock. After the upward time preference shock, the vertical line $\frac{dc_t}{dt} = 0$ moves to the left (from the solid vertical line to the dashed vertical line in Fig. 1). To keep Pareto efficiency, consumption needs to jump immediately from the steady state before the shock (the prior steady state) to point *Z*. After the jump, consumption proceeds on the Pareto efficient saddle path after the shock (the posterior Pareto efficient saddle path) from point *Z* to the lower steady state after the shock (the posterior steady state). Nevertheless, this discontinuous jump to *Z* may be uncomfortable for risk-averse households that wish to smooth consumption and not to experience substantial fluctuations. Households may instead take a shortcut and, for example, proceed on a path on which consumption is reduced continuously from the prior steady state to the posterior steady state (the bold dashed line in Figure 1, but this shortcut is not Pareto efficient.

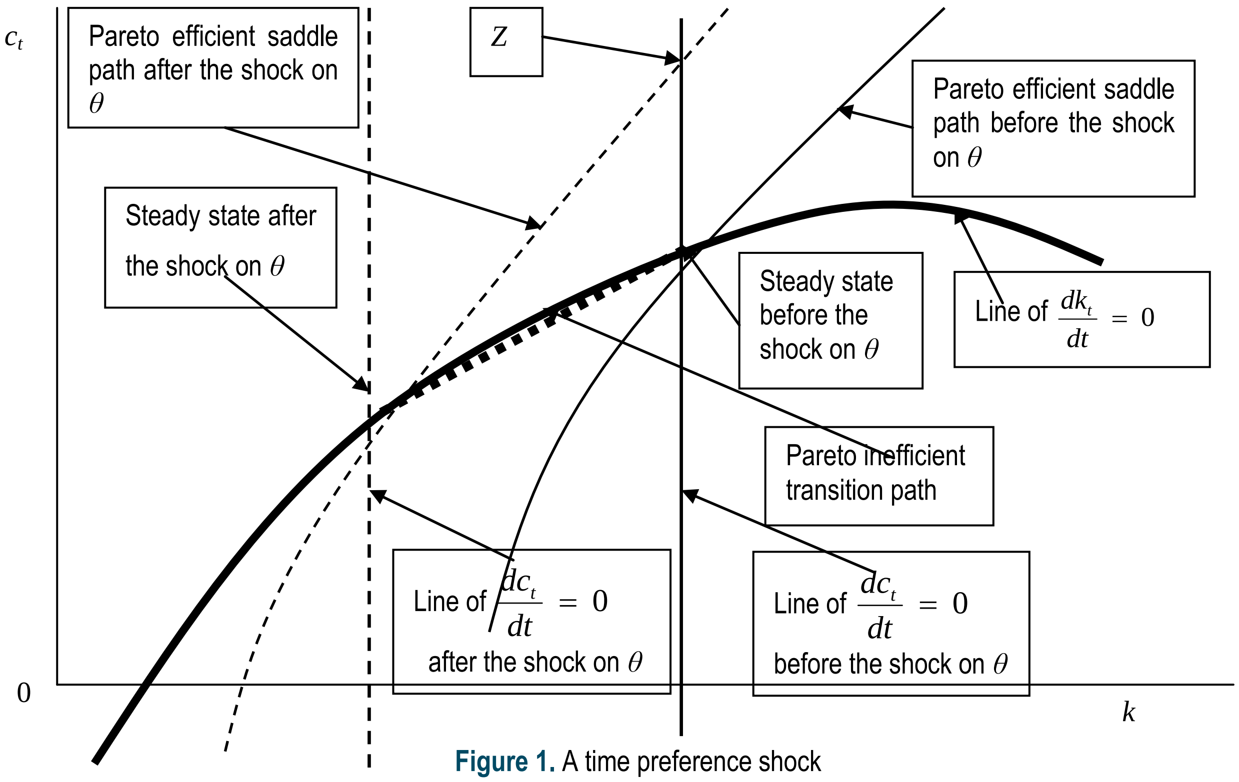

Figure 1. A time preference shock

Choosing a Pareto inefficient consumption path must be consistent with each household's maximization of its expected utility. To examine the possibility of the rational choice of a Pareto inefficient path, the expected utilities between the two options need be compared. For this comparison, I assume that there are two options for each non-cooperative household with regard to consumption just after an upward shift in time preference. The first is a jump option, *J*, in which a household's consumption jumps to *Z* and then proceeds on the posterior Pareto efficient saddle path to the posterior steady state. The second is a non-jump option, *NJ*, in which a household's consumption does not jump but instead gradually decreases from the prior steady state to the posterior steady state, as shown by the bold dashed line in Figure 1. The household that chooses the *NJ* option reaches the posterior steady state in period $s(\geq 0)$. The difference in consumption between the two options in each period *t* is

b_t (≥ 0). Thus, b_0 indicates the difference between *Z* and the prior steady state. b_t diminishes continuously and becomes zero in period *s*. The *NJ* path of consumption (c_t) after the shock is monotonously continuous and differentiable in *t* and $\frac{dc_t}{dt} < 0$ if $0 \le t < s$. In addition,

$$\bar{c} < c_t < \hat{c}_t \text{ if } 0 \le t < s$$

$$c_t = \bar{c} \text{ if } 0 \le s \le t,$$

where $\hat{c}_t$ is consumption when proceeding on the posterior Pareto efficient saddle path and $\bar{c}$ is consumption in the posterior steady state. Therefore,

$$b_t = \hat{c}_t - c_t > 0 \text{ if } 0 \le t < s$$

$$b_t = 0 \text{ if } 0 \le s \le t.$$

It is also assumed that, when a household chooses a different option from the one the other households choose, the difference in the accumulation of financial assets resulting from the difference in consumption (b_t) before period *s* between that household and the other households is reflected in consumption after period *s*. That is, the difference in the return on financial assets is added to (or subtracted from) the household's consumption in each period after period *s*. The exact functional form of the addition (or subtraction) is shown in Section 3.1.4.

3.1.3. Firms

Unutilized products (b_t) are eliminated quickly in each period by firms because holding b_t for a long period is a cost to firms. Elimination of b_t is accomplished by discarding the goods or preemptively suspending production, thereby leaving some capital and labor inputs idle. However, in the next period, unutilized products are generated again because the economy is not proceeding on the Pareto efficient saddle path.

Unutilized products are therefore successively generated and eliminated. Faced with these unutilized products firms dispose of the excess capital used to generate b_t. Disposing of the excess capital is rational for firms because the excess capital is an unnecessary cost, but this means that parts of the firms are liquidated, which takes time and thus disposing of the excess capital will also take time. If the economy proceeds on the *NJ* path (that is, if all households choose the *NJ* option), firms dispose of all of the remaining excess capital that generates b_t and adjust their capital to the posterior steady-state level in period *s*, which also corresponds to households reaching the posterior steady state. Thus, if the economy proceeds on the *NJ* path, capital k_t is

$$\bar{k} < k_t \le \hat{k}_t \text{ if } 0 \le t < s$$

$$k_t = \bar{k} \text{ if } 0 \le s \le t,$$

where $\hat{k}_t$ is capital per capita when proceeding on the posterior Pareto efficient saddle path and $\bar{k}$ is capital per capita in the posterior steady state.

The real interest rate i_t is

$$i_t = \frac{\partial f(A, k_t)}{\partial k_t}.$$

Because the real interest rate equals the rate of time preference at steady state, if the economy proceeds on the *NJ* path,

$\tilde{\theta} \le i_t < \theta$ if $0 \le t < s$

$i_t = \theta$ if $0 \le s \le t$,

where $\tilde{\theta}$ is the rate of time preference before the shock and θ is the rate of time preference after the shock. i_t is monotonously continuous and differentiable in *t* if $0 \le t < s$.

3.1.4. Expected utility after the shock

The expected utility of a household after the shock depends on its choice of the *J* or *NJ* path. Let *Jalone* indicate that the household chooses option *J*, but the other households choose option *NJ*; *NJalone* indicate that the household chooses option *NJ*, but the other households choose option *J*; *Jtogether* indicate that all households choose option *J*; and *NJtogether* indicate that all households choose option *NJ*. Let *p* (0 ≤ *p* ≤ 1) be the subjective probability of a household that the other households choose the *J* option (e.g., *p* = 0 indicates that all the other households choose option *NJ*). With *p*, the expected utility of a household when it chooses option *J* is:

$$E_0(J) = pE_0(Jtogether) + (1-p)E_0(Jalone), \tag{25}$$

and when it chooses option *NJ* is:

$$E_0(NJ) = pE_0(NJalone) + (1-p)E_0(NJtogether), \tag{26}$$

where $E_0(Jalone)$, $E_0(NJalone)$, $E_0(Jtogether)$, and $E_0(NJtogether)$ are the expected utilities of the household when choosing *Jalone*, *NJalone*, *Jtogether*, and *NJtogether*, respectively. Given the properties of *J* and *NJ* shown in Sections 3.1.2 and 3.1.3,

$$E_0(J) = pE_0\left[\int_0^s \exp(-\theta t) u(c_t + b_t) dt + \int_s^\infty \exp(-\theta t) u(\hat{c}_t) dt\right]$$
$$+ (1-p)E_0\left[\int_0^s \exp(-\theta t) u(c_t + b_t) dt + \int_s^\infty \exp(-\theta t) u(\bar{c} - \bar{a}) dt\right], \tag{27}$$

and

$$E_0(NJ) = pE_0\left[\int_0^s \exp(-\theta t) u(c_t) dt + \int_s^\infty \exp(-\theta t) u(\hat{c}_t + a_t) dt\right]$$
$$+ (1-p)E_0\left[\int_0^s \exp(-\theta t) u(c_t) dt + \int_s^\infty \exp(-\theta t) u(\bar{c}) dt\right], \tag{28}$$

where:

$$\bar{a} = \theta \int_0^s b_r \exp \int_r^s i_q \, dq \, dr, \tag{29}$$

and

$$a_t = i_t \int_0^s b_r \exp \int_r^s i_q \, dq \, dr, \tag{30}$$

and the shock occurred in period *t* = 0. Figure 2 shows the paths of *Jalone* and *NJalone*. Because there is a sufficiently large number of households and the effect of an individual household on the whole economy is negligible, in the case of *Jalone*, the economy almost proceeds on the *NJ* path. Similarly, in the case of *NJalone*, it almost proceeds on the *J* path. If the other households choose the *NJ* option (*Jalone* or *NJtogether*), consumption after *s* is constant as $\bar{c}$ and capital is adjusted to $\bar{k}$ by firms in period *s*. In addition, a_t and i_t are constant after *s* such that a_t equals $\bar{a}$ and i_s equals *θ*, because the economy is at the posterior steady state. Nevertheless, during the transition period before *s*, the value of i_t changes from the value of the prior time preference rate to that of the posterior rate. If the other households choose option *J* (*NJalone* or *Jtogether*), however, consumption after *s* is $\hat{c}_t$ and capital is not adjusted to $\bar{k}$ by firms in period *s* and remains at $\hat{k}_t$.

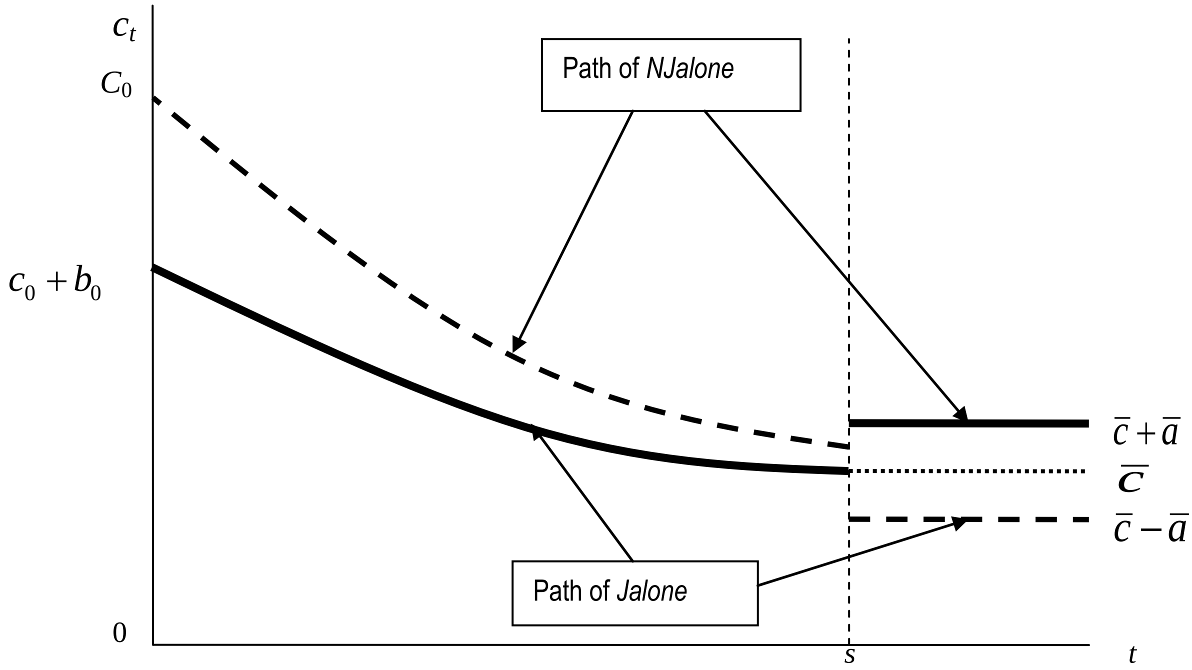

Figure 2. The paths of *Jalone* and *NJalone*

As mentioned in Section 3.1.2, the difference in the returns on financial assets for the household from the returns for each of the other households is added to (or subtracted from) its consumption in each period after period *s*. This is described by a_t and $\bar{a}$ in Eqs. (27) and (28), and Eqs. (29) and (30) indicate that the accumulated difference in financial assets resulting from b_t increases by compound interest between the period *r* to *s*. That is, if the household takes the *NJalone* path, it accumulates more financial assets than each of the other *J* households, and instead of immediately consuming these extra accumulated financial assets after period *s*, the household consumes the returns on them in every subsequent period. If the household takes the *Jalone* path, however, its consumption after *s* is $\bar{c} - \bar{a}$, as shown in Eq. (27). $\bar{a}$ is subtracted because the income of each household, $y_t = f(A, k_t)$, including the *Jalone* household, decreases equally by b_t. Each of the other *NJ* households decreases consumption by b_t at the same time, which compensates for the decrease in income; thus, its financial assets (i.e., capital per capita; k_t) are kept equal to $\hat{k}_t$. The *Jalone* household, however, does not decrease its consumption, and its financial assets become smaller than those of each of the other *NJ* households, which results in the subtraction of $\bar{a}$ after period *s*.

3.2. Pareto inefficient transition path [28]

3.2.1. Rational Pareto inefficient path

3.2.1.1. Rational choice of a Pareto inefficient path

Before examining the economy with non-cooperative households, I first show that, if households are cooperative, only option *J* is chosen as the path after the shock because it gives a higher expected utility than option *NJ*. Because there is no possibility of *Jalone* and *NJalone* if households are cooperative, then $E_0(J) = E_0(Jtogether)$ and $E_0(NJ) = E_0(NJtogether)$. Therefore,

$$E_0(J) - E_0(NJ)$$
$$= E_0\left[\int_0^s \exp(-\theta t)u(c_t + b_t)dt + \int_s^\infty \exp(-\theta t)u(\hat{c}_t)dt\right] - E_0\left[\int_0^s \exp(-\theta t)u(c_t)dt + \int_s^\infty \exp(-\theta t)u(\bar{c})dt\right]$$

[28] The idea of a rationally chosen Pareto inefficient path was originally presented by Harashima (2004b).

$$= E_0\left\{\int_0^s \exp(-\theta t)[u(c_t + b_t) - u(c_t)]dt + \int_s^\infty \exp(-\theta t)[u(\hat{c}_t) - u(\bar{c})]dt\right\} > 0$$

because $c_t < c_t + b_t$ and $\bar{c} < \hat{c}_t$.

Next, I examine the economy with non-cooperative households. First, the special case with a utility function with a sufficiently small γ is examined.

Lemma 1: If $\gamma(0 < \gamma < \infty)$ is sufficiently small, then $E_0(Jalone) - E_0(NJtogether) > 0$.

Proof: $\lim_{\gamma\to 0}[E_0(Jalone) - E_0(NJtogether)]$

$$= E_0\int_0^s \exp(-\theta t)\lim_{\gamma\to 0}[u(c_t + b_t) - u(c_t)]dt + E_0\int_s^\infty \exp(-\theta t)\lim_{\gamma\to 0}[u(\bar{c} - \bar{a}) - u(\bar{c})]dt$$

$$= E_0\int_0^s \exp(-\theta t) b_t\, dt - E_0\int_s^\infty \exp(-\theta t)\bar{a}\, dt$$

$$= E_0\int_0^s \exp(-\theta t) b_t dt - E_0\theta\left[\int_0^s\left(b_r \exp\int_r^s i_q\, dq\right)dr\right]\int_s^\infty \exp(-\theta t)dt$$

$$= E_0\int_0^s \exp(-\theta t) b_t dt - E_0 \exp(-\theta s)\int_0^s\left(b_r \exp\int_r^s i_q\, dq\right)dr$$

$$= E_0 \exp(-\theta s)\int_0^s b_t \left\{\exp[\theta(s-t)] - \exp\int_t^s i_q\, dq\right\}dt > 0,$$

because, if $0 \le t < s$, then $i_t < \theta$ and $\exp[\theta(s-t)] > \exp\int_t^s i_q\, dq$. Hence, because $\exp[\theta(s-t)] > \exp\int_t^s i_q\, dq$, $E_0(Jalone) - E_0(NJtogether) > 0$ for sufficiently small γ.

Second, the opposite special case (i.e., a utility function with a sufficiently large γ) is examined.

Lemma 2: If $\gamma(0 < \gamma < \infty)$ is sufficiently large and if $0 < \lim_{\gamma\to\infty}\frac{\bar{a}}{\bar{c}} < 1$, then $E_0(Jalone) - E_0(NJtogether) < 0$.

Proof: Because $0 < b_t$, then

$$\lim_{\gamma\to\infty}\frac{1-\gamma}{\bar{c}^{\,1-\gamma}}[u(c_t + b_t) - u(c_t)] = \lim_{\gamma\to\infty}\left[\left(\frac{c_t + b_t}{\bar{c}}\right)^{1-\gamma} - \left(\frac{c_t}{\bar{c}}\right)^{1-\gamma}\right] = 0$$

for any period $t(< s)$. On the other hand, because $0 < \bar{a}$, then for any period $t(< s)$, if $0 < \lim_{\gamma\to\infty}\frac{\bar{a}}{\bar{c}} < 1$,

$$\lim_{\gamma\to\infty}\frac{1-\gamma}{\bar{c}^{\,1-\gamma}}[u(\bar{c} - \bar{a}) - u(\bar{c})] = \lim_{\gamma\to\infty}\left[\left(1 - \frac{\bar{a}}{\bar{c}}\right)^{1-\gamma} - 1\right] = \infty.$$

Thus, $\lim_{\gamma\to\infty}\frac{1-\gamma}{\bar{c}^{\,1-\gamma}}[E_0(Jalone) - E_0(NJtogether)]$

$$= \lim_{\gamma\to\infty}\frac{1-\gamma}{\bar{c}^{\,1-\gamma}}\int_0^s \exp(-\theta t)\lim_{\gamma\to\infty}[u(c_t + b_t) - u(c_t)]dt$$

$$+ \lim_{\gamma\to\infty}\frac{1-\gamma}{\bar{c}^{\,1-\gamma}}\int_s^\infty \exp(-\theta t)\lim_{\gamma\to\infty}[u(\bar{c} - \bar{a}) - u(\bar{c})]dt$$

$= 0 + \infty > 0$. Because $\frac{1-\gamma}{\bar{c}^{\,1-\gamma}} < 0$ for any $\gamma(1 < \gamma < \infty)$, then if $0 < \lim_{\gamma\to\infty}\frac{\bar{a}}{\bar{c}} < 1$, $E_0(Jalone) - E_0(NJtogether) < 0$ for sufficiently large $\gamma(< \infty)$.

The condition $0 < \lim_{\gamma\to\infty}\frac{\bar{a}}{\bar{c}} < 1$ indicates that path *NJ* from c_0 to $\bar{c}$ deviates sufficiently from the posterior Pareto efficient saddle path and reaches the posterior steady state $\bar{c}$ not taking much time. Because steady states are irrelevant to the degree of risk aversion (γ), both c_0 and $\bar{c}$ are irrelevant to γ.

By Lemmas 1 and 2, it can be proved that $E_0(Jalone) - E_0(NJtogether) < 0$ is possible.

Lemma 3: If $0 < \lim_{\gamma \to \infty} \frac{\bar{a}}{\bar{c}} < 1$, then there is a $\gamma^*(0 < \gamma^* < \infty)$ such that if $\gamma^* < \gamma < \infty$, $E_0(Jalone) - E_0(NJtogether) < 0$.

Proof: If $\gamma(> 0)$ is sufficiently small, then $E_0(Jalone) - E_0(NJtogether) > 0$ by Lemma 1, and if $\gamma(< \infty)$ is sufficiently large and if $0 < \lim_{\gamma \to \infty} \frac{\bar{a}}{\bar{c}} < 1$, then $E_0(Jalone) - E_0(NJtogether) < 0$ by Lemma 2. Hence, if $0 < \lim_{\gamma \to \infty} \frac{\bar{a}}{\bar{c}} < 1$, there is a certain $\gamma^*(0 < \gamma^* < \infty)$ such that, if $\gamma^* < \gamma < \infty$, then $E_0(Jalone) - E_0(NJtogether) < 0$.

However, $E_0(Jtogether) - E_0(NJalone) > 0$ because both *Jtogether* and *NJalone* indicate that all the other households choose option *J*; thus, the values of i_t and k_t are the same as those when all households proceed on the posterior Pareto efficient saddle path. Faced with these - i_t and k_t, - deviating alone from the Pareto efficient path (*NJalone*) gives a lower expected utility than *Jtogether* to the *NJ* household. Both *Jalone* and *NJtogether* indicate that all the other households choose option *NJ* and i_t and k_t are not those of the Pareto efficient path. Hence, the sign of $E_0(Jalone) - E_0(NJtogether)$ varies depending on the conditions, as Lemma 3 indicates.

By Lemma 3 and the property $E_0(Jtogether) - E_0(NJalone) > 0$, the possibility of the choice of a Pareto inefficient transition path, that is, $E_0(J) - E_0(NJ) < 0$, is shown.

Proposition 1: If $0 < \lim_{\gamma \to \infty} \frac{\bar{a}}{\bar{c}} < 1$ and $\gamma^* < \gamma < \infty$, then there is a $p^*(0 \le p^* \le 1)$ such that if $p = p^*$, $E_0(J) - E_0(NJ) = 0$, and if $p < p^*$, $E_0(J) - E_0(NJ) < 0$.

Proof: By Lemma 3, if $\gamma^* < \gamma < \infty$, then $E_0(Jalone) - E_0(NJtogether) < 0$ and $E_0(Jtogether) - E_0(NJalone) > 0$. By Eqs. (25) and (26), $E_0(J) - E_0(NJ) = p[E_0(Jtogether) - E_0(NJalone)] + (1-p)[E_0(Jalone) - E_0(NJtogether)]$.

Thus, if $0 < \lim_{\gamma \to \infty} \frac{\bar{a}}{\bar{c}} < 1$ and, $\lim_{p \to 0} [E_0(J) - E_0(NJ)] = E_0(Jalone) - E_0(NJtogether) < 0$ and $\lim_{p \to 1} [E_0(J) - E_0(NJ)] = E_0(Jtogether) - E_0(NJalone) > 0$. Hence, by the intermediate value theorem, there is $p^*(0 \le p^* \le 1)$ such that if $p = p^*$, $E_0(J) - E_0(NJ) = 0$ and if $p < p^*$, $E_0(J) - E_0(NJ) < 0$.

Proposition 1 indicates that, if $0 < \lim_{\gamma \to \infty} \frac{\bar{a}}{\bar{c}} < 1$, $\gamma^* < \gamma < \infty$, and $p < p^*$, then the choice of option *NJ* gives the higher expected utility than that of option *J* to a household; that is, a household may make the rational choice of taking a Pareto inefficient transition path. The lemmas and proposition require no friction, so a Pareto inefficient transition path can be chosen even in a frictionless economy. This result is very important because it offers counter-evidence against the conjecture that households never rationally choose a Pareto inefficient transition path in a frictionless economy.

3.2.1.2. Conditions for a rational Pareto inefficient path

The proposition requires several conditions. Among them, $\gamma^* < \gamma < \infty$ may appear rather strict. If γ^* is very large, path *NJ* will rarely be chosen. However, if path *NJ* is such that consumption is reduced sharply after the shock, the *NJ* option yields a higher expected utility than the *J* option even though γ is very small. For example, for any $\gamma(0 < \gamma < \infty)$, $\lim_{s \to 0} \frac{1}{s}[E_0(Jalone) - E_0(NJtogether)]$

$$= \lim_{s \to 0} \frac{1}{s} \int_0^s \exp(-\theta t)[u(c_t + b_t) - u(c_t)]dt + \lim_{s \to 0} \frac{1}{s} \int_s^\infty \exp(-\theta t)[u(\bar{c} - \bar{a}) - u(\bar{c})]dt$$

$$= u(c_0 + b_0) - u(c_0) - \frac{1}{\theta}\lim_{s\to 0}\frac{u(\bar{c}) - u(\bar{c} - s\theta b_0)}{s} = u(c_0 + b_0) - u(c_0) - b_0\frac{du(\bar{c})}{d\bar{c}}$$

$$= \frac{(c_0 + b_0)^{1-\gamma} - c_0^{1-\gamma}}{1-\gamma} - b_0\bar{c}^{-\gamma} = \bar{c}^{-\gamma}\left\{\bar{c}^{\gamma}\left[\frac{(c_0 + b_0)^{1-\gamma}}{1-\gamma} - \frac{c_0^{1-\gamma}}{1-\gamma}\right] - b_0\right\} < 0,$$

because $\lim_{\gamma\to 1}\bar{c}^{\gamma}\left[\frac{(c_0 + b_0)^{1-\gamma}}{1-\gamma} - \frac{c_0^{1-\gamma}}{1-\gamma}\right] = \bar{c}[\ln(c_0 + b_0) - \ln(c_0)] = \bar{c}\ln\left(1 + \frac{b_0}{c_0}\right) < b_0$ and $\lim_{\gamma\to\infty}\bar{c}^{\gamma}\left[\frac{(c_0 + b_0)^{1-\gamma}}{1-\gamma} - \frac{c_0^{1-\gamma}}{1-\gamma}\right] = \lim_{\gamma\to\infty}\bar{c}^{\gamma}c_0^{1-\gamma}\left[\frac{\left(1 + \frac{b_0}{c_0}\right)^{1-\gamma} - 1}{1-\gamma}\right] = 0$ because $\bar{c} < c_0$. That is, for each combination of path *NJ* and γ, there is $s^*(>0)$ such that, if $s < s^*$, then $E_0(Jalone) - E_0(NJtogether) < 0$. Consider an example in which path *NJ* is such that b_t is constant and $b_t = \bar{b}$ before *s* (Figure 3):

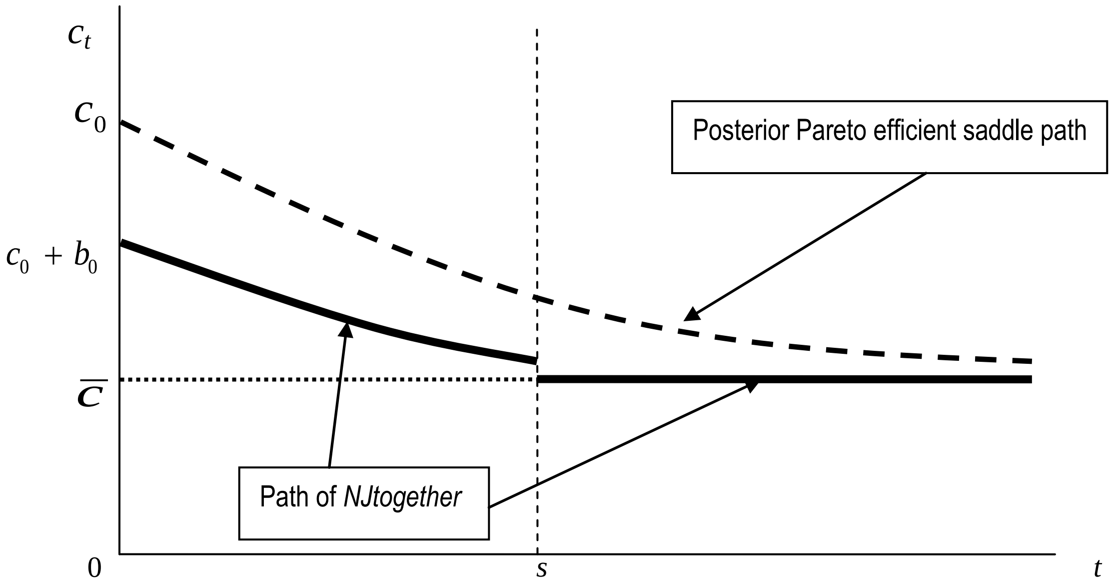

Figure 3. A Pareto inefficient transition path

thus, $E_0\int_0^s b_t = s\bar{b}$. In this *NJ* path, consumption is reduced more sharply than it is in the case shown in Figure 2. In this case, because $\bar{a} > E_0\theta\int_0^s b_t = \theta s\bar{b}$, $0 < \gamma$, and $c_s < c_t$ for $t < s$, then

$E_0\int_0^s \exp(-\theta t)[u(c_t + b_t) - u(c_t)]dt < E_0\int_0^s \exp(-\theta t)dt[u(c_s + \bar{b}) - u(c_s)] =$
$E_0\frac{1 - \exp(-\theta s)}{\theta}[u(c_s + \bar{b}) - u(c_s)]$, and in addition, $E_0\int_s^\infty \exp(-\theta t)[u(\bar{c} - \bar{a}) - u(\bar{c})]dt =$
$E_0\int_s^\infty \exp(-\theta t)dt[u(\bar{c} - \bar{a}) - u(\bar{c})] = E_0\frac{\exp(-\theta s)}{\theta}[u(\bar{c} - \bar{a}) - u(\bar{c})] < E_0\frac{\exp(-\theta s)}{\theta}[u(\bar{c} - \theta s\bar{b}) - u(\bar{c})]$.

Hence, $E_0(Jalone) - E_0(NJtogether)$

$$= E_0\int_0^s \exp(-\theta t)[u(c_t + b_t) - u(c_t)]dt + E_0\int_s^\infty \exp(-\theta t)[u(\bar{c} - \bar{a}) - u(\bar{c})]dt$$

$$< E_0\frac{1 - \exp(-\theta s)}{\theta}[u(c_s + \bar{b}) - u(c_s)] + E_0\frac{\exp(-\theta s)}{\theta}[u(\bar{c} - \theta s\bar{b}) - u(\bar{c})]$$

$$= E_0 \frac{1-\exp(-\theta s)}{\theta}\left\{\left[u\left(c_s+\bar{b}\right)-u\left(c_s\right)\right]-\frac{\exp(-\theta s)}{1-\exp(-\theta s)}\left[u\left(\bar{c}\right)-u\left(\bar{c}-\theta s\bar{b}\right)\right]\right\}.$$

As γ increases, the ratio $\frac{u\left(c_s+\bar{b}\right)-u\left(c_s\right)}{u\left(\bar{c}\right)-u\left(\bar{c}-\theta s\bar{b}\right)}$ decreases; thus, larger values of s can satisfy $E_0(Jalone)-E_0(NJtogether)<0$. For example, suppose that $\bar{c}$ = 10, c_s = 10.2, $\bar{b}$ = 0.3, and θ = 0.05. If $\gamma = 1$, then s^* = 1.5 at the minimum, and if $\gamma = 5$, then s^* = 6.8 at the minimum. This result implies that, if option *NJ* is such that consumption is reduced relatively sharply after the shock (e.g., $b_t = \bar{b}$) and $p < p^*$, option *NJ* will usually be chosen. Choosing option *NJ* is not a special case observed only if γ is very large, but option *NJ* can normally be chosen when the value of γ is within usually observed values. Conditions for generating a rational Pareto inefficient transition path therefore are not strict. In a recession, consumption usually declines sharply after the shock, which suggests that households have chosen the *NJ* option.

3.3. Nash equilibrium

3.3.1. A Nash equilibrium consisting of NJ strategies

A household strategically determines whether to choose the *J* or *NJ* option, considering other households' choices. All households know that each of them forms expectations about the future values of its utility and makes a decision in the same manner. Since all households are identical, the best response of each household is identical. Suppose that there are $H\,(\in N)$ identical households in the economy where *H* is sufficiently large (as assumed in Section 3.1). Let $q_\eta \; (0 \le q_\eta \le 1)$ be the probability that a household $\eta\,(\in H)$ chooses option *J*. The average utility of the other households almost equals that of all households because *H* is sufficiently large. Hence, the average expected utilities of the other households that choose the *J* and *NJ* options are E_0(*Jtogether*) and E_0(*NJtogether*), respectively. Hence, the payoff matrix of the *H*-dimensional symmetric mixed strategy game can be described as shown in Table 1. Each identical household determines its behavior on the basis of this payoff matrix.

Table 1. The payoff matrix

	Any other household	
	J	*NJ*
J	E_0(*Jtogether*), E_0(*Jtogether*)	E_0(*Jalone*), E_0(*NJtogether*)
NJ	E_0(*NJalone*), E_0(*Jtogether*)	E_0(*NJtogether*), E_0(*NJtogether*)

In this mixed strategy game, the strategy profiles: (q_1,q_2,…,q_H) = {(1,1,…,1), ($p^*, p^*,..., p^*$), (0,0,…,0)} are Nash equilibria for the following reason. By Proposition 1, the best response of household η is *J* (i.e., q_η = 1) if $p > p^*$, indifferent between *J* and *NJ* (i.e., any $q_\eta \in [0,1]$) if $p = p^*$, and *NJ* (i.e., q_η = 0) if $p < p^*$. Because all households are identical, the best-response correspondence of each household is identical such that q_η = 1 if $p > p^*$, [0,1] if $p = p^*$, and 0 if $p < p^*$ for any household $\eta \in H$. Hence, the mixed strategy profiles (1, 1,…,1), ($p^*, p^*,..., p^*$), and (0,0,…,0) are the intersections of the graph of the best-response correspondences of all households. The Pareto efficient saddle path solution (1,1,…,1) (i.e., *Jtogether*) is a pure strategy Nash equilibrium, but a Pareto inefficient transition path (0,0,…,0) (i.e., *NJtogether*) is also a pure strategy Nash equilibrium. In addition, there is a mixed strategy Nash equilibrium ($p^*, p^*,..., p^*$).

3.3.2. Selection of equilibrium

Determining which Nash equilibrium, either *NJtogether* (0,0,…,0) or *Jtogether* (1,1,…,1), is dominant requires refinements of the Nash equilibrium, which necessitate additional criteria. Here, if households have a risk-averse preference in the sense that they avert the worst scenario when its probability is not known, households suppose a very low p and select the *NJtogether* (0,0,…,0) equilibrium. Because, $E_0(Jalone) - E_0(NJalone)$

$$= E_0 \left\{ \int_0^s \exp(-\theta t)[u(c_t + b_t) - u(c_t)]dt + \int_s^\infty \exp(-\theta t)[u(\bar{c} - \bar{a}) - u(\hat{c}_t + a_t)]dt \right\}$$

$$< E_0 \left\{ \int_0^s \exp(-\theta t)[u(c_t + b_t) - u(c_t)]dt + \int_s^\infty \exp(-\theta t)[u(\bar{c} - \bar{a}) - u(\bar{c})]dt \right\}$$

$$= E_0(Jalone) - E_0(NJtogether) < 0, \qquad (31)$$

by Lemma 3, *Jalone* is the worst choice in terms of the amount of payoff, followed by *NJtogether*, and *NJalone*, and *Jtogether* is the best. The outcomes of choosing option *J* are more dispersed than those of option *NJ*. If households have a risk-averse preference in the above-mentioned sense and avert the worst scenario when they have no information on its probability, a household will prefer the less dispersed option (*NJ*), fearing the worst situation that the household alone substantially increases consumption while the other households substantially decrease consumption after the shock. This behavior is rational because it is consistent with preferences. Because all households are identical and know inequality (31), all households will equally suppose that they all prefer the less dispersed *NJ* option; therefore, all of them will suppose a very low p, particularly $p = 0$, and select the *NJtogether* (0,0,…,0) equilibrium, which is the Nash equilibrium of a Pareto inefficient path. Thereby, unlike most multiple equilibria models, the problem of indeterminacy does not arise, and "animal spirits" (e.g., pessimism or optimism) are unnecessary to explain the selection.

3.4. Amplified generation of unutilized resources

The Nash equilibrium of a Pareto inefficient path successively generates unutilized products (b_t). They are left unused, discarded, or preemptively not produced during the path. Unused or discarded goods and services indicate a decline in sales and an increase in inventory for firms. Preemptively suspended production results in an increase in unemployment and idle capital. As a result, profits decline and some parts of firms need to be liquidated, which is unnecessary if the economy proceeds on the *J* path (i.e., the posterior Pareto efficient path). If the liquidation is implemented immediately after the shock, b_t will no longer be generated, but such a liquidation would generate a tremendous shock. The process of the liquidation, however, will take time because of various frictions, and excess capital that generates b_t will remain for a long period. During the period when capital is not reduced to the posterior steady-state level, unutilized products are successively generated. In a period, b_t is generated and eliminated, but in the next period, another, new, b_t is generated and eliminated. This cycle is repeated in every period throughout the transition path, and it implies that demand is lower than supply in every period. This phenomenon may be interpreted as a general glut or a persisting disequilibrium by some definitions of equilibrium. That is, b_t is another source of output gaps than frictions.

3.5. Time preference shock as the exceptional shock

Not all shocks result in Nash equilibrium of a Pareto inefficient path. If anything, this type of shock is limited because such a shock needs to force consumption to fluctuate very jaggedly to maintain Pareto efficiency. A Pareto inefficient path is preferred, because these substantially jagged fluctuations can be averted. An upward time preference shock is one shock that necessitates a substantially jagged fluctuation as shown in Figure 1. Other examples are rare because shocks that do not change the steady state (e.g., monetary shocks) are not relevant. One other example is technology regression, which would move the vertical line $\frac{dc_t}{dt} = 0$ to the left in Figure 1 and necessitate a jagged consumption path to keep Pareto efficiency. In this sense, technology and time preference shocks have similar effects on economic fluctuations. However, a technology regression also simultaneously moves the curve $\frac{dk_t}{dt} = 0$ downwards, and accordingly, the Pareto efficient saddle path also moves downwards.

Therefore, the jagged consumption is smoothed out to some extent. As a result, the substantially jagged consumption that can generate a recession would require a large-scale, sudden, and sharp regression in technology, which does not seem very likely. An upward time preference shock, however, only moves the vertical line $\frac{dc_t}{dt} = 0$ to the left.

In some macro-economic models with multiple equilibria, changing equilibria may necessitate substantially jagged consumption to keep Pareto optimality. There are many types of multiple equilibra models that depend on various types of increasing returns, externalities, or complementarities, but they are vulnerable to a number of criticisms (e.g., insufficient explanation of the switching mechanism; see, e.g., Morris and Shin, 2001). Examining the properties, validity, and plausibility of each of these many and diverse models is beyond the scope of this paper.

4. Phillips curve

4.1. Models of the Phillips curve

4.1.1. Trend inflation and inflation

The micro-foundation of trend inflation discussed in Section 2 indicates that inflation π_t is a function of trend inflation π_t^T, in particular such that:

$$\pi_t = \pi_t^T + v_{1,t}, \tag{32}$$

where $v_{1,t}$ is a variable that represents factors other than trend inflation in period *t*. Equation (32) indicates that the aggregate supply equation (the Phillips curve) is modeled as a variable moving around a trend and occasionally diverting from the trend because of other factors.

4.1.2. Output gaps and inflation

Section 2 shows that shifts in θ_P change the path of trend inflation (π_t^T) unless θ_G is immediately changed in the same direction and by the same magnitude as θ_P. Usually θ_G will not change immediately after a shift in θ_P, so the path of trend inflation will usually change after a shift in θ_P. Hence, π_t changes as θ_P shifts; thus, π_t is a function of θ_P such that:

$$\pi_t = h_\theta\left(\theta_{P,t}\right). \tag{33}$$

In Section 3, I showed that outputs y_t fluctuate with shifts of θ_P and unutilized resources (b_t) are generated. The unutilized resources indicate the existence of output gaps. The output gaps x_t can be described as follows: $x_t = \ln(y_t) - \ln(\tilde{y}_t)$, *where* $\tilde{y}_t$ is y_t at the steady state or on the saddle path. Let also: $x_{b,t} = \ln(y_t) - \ln(y_t + b_t)$.

That is, $x_{b,t}$ is the output gap generated owing to b_t in period *t* and is a part of x_t. Because b_t is a function of θ_P, $x_{b,t}$ is also a function of θ_P such that:

$$x_{b,t} = h_b\left(\theta_{P,t}\right), \tag{34}$$

where $\theta_{P,t}$ is θ_P in period *t*.

Suppose that $\theta_{P,t}$ is a Markov process and shifts in θ_P occasionally occur. By Eqs. (33) and (34), $x_{b.t}$ will be observed to correlate with π_t such that:

$$\pi_t = h_\theta\left[h_b^{-1}\left(x_{b,t}\right)\right]. \tag{35}$$

Equation (35) does not indicate causation; it merely indicates that there is a correlation between π_t and $x_{b,t}$. The causations are described by Eqs. (33) and (34).

There is, however, a conventional correlation between inflation and output gaps, and it is caused by frictions in price flexibility. The output gaps generated by frictions are traditionally thought to be the only sources of output gaps in the NKPC. Suppose that the sources of output gaps are only b_t and frictions. Thus, the output gaps that are generated by frictions in period t are: $x_{F,t} = \ln(y_t + b_t) - \ln(\tilde{y}_t)$. That is, $x_t = x_{b,t} + x_{F,t}$.

According to the micro-foundation of the NKPC, $x_{F,t}$ is correlated with π_t in a forward-looking manner such that:

$$\pi_t = h_F\left(x_{F,t+i|t-1}\right) + v_{2,t} \quad \text{for } i = 0,1,2 \tag{36}$$

where $v_{2,t}$ is a variable that represents factors other than trend inflation and $x_{F,t+i|t-1}$ is the $x_{F,t+i}$ expected in period t – 1.

4.1.3. Three models of inflation in the aggregate supply equation

Combining Eqs. (32) and (36), inflation can be modeled as

$$\pi_t = \pi_t^T + h_F\left(x_{F,t+i|t-1}\right) \quad \text{for } i = 0,1,2,.....$$

With i.i.d. shocks ε_t, the data generation mechanism of π_t can be modeled as

$$\pi_t = \pi_t^T + h_F\left(x_{F,t+i|t-1}\right) + \varepsilon_{1,t} \quad \text{for } i = 0,1,2,..... \tag{37}$$

or more simply

$$\pi_t = a_1\pi_t^T + \varphi_1 x_{F,t|t-1} + \varepsilon_{1,t}\,, \tag{38}$$

where a_1 and φ_1 are constants and expected to be positive, and $\varepsilon_{1,t}$ is an i.i.d. shock in period t. It is important to note that Eqs. (37) and (38) are aggregate supply equations that are firmly constructed on a micro-foundation basis. Another important point is that Eqs. (37) and (38) do not include the correlation indicated by Eq. (35).

Equations (37) and (38) superficially resemble the pure NKPC and the hybrid NKPC, but they are actually completely different. Typical pure and hybrid NKPCs can be described, respectively, as

$$\pi_t = \varphi_2 x_{F,t|t-1} + \varepsilon_{2,t} \tag{39}$$

and

$$\pi_t = a_3\pi_{t-1} + \varphi_3 x_{F,t|t-1} + \varepsilon_{3,t}\,, \tag{40}$$

where a_3, φ_2, and φ_3 are constants and expected to be positive, and $\varepsilon_{2,t}$ and $\varepsilon_{3,t}$ are disturbances in period t. That is, a pure NKPC indicates that inflation is a function of $x_{F,t}$ and a hybrid NKPC indicates that inflation is a function of both lagged inflation and $x_{F,t}$. An important difference between Eq.(38) and Eqs. (39) and (40) is that Eq. (38) includes trend inflation but the others do not.

Conceptually, most models of NKPC assume that $x_{b,t}$ does not exist and x_t consists only of $x_{F,t}$ as shown in Eqs. (39) and (40), and data of x_t are usually regarded to be identical to those of $x_{F,t}$. However, if $x_{b,t}$ does exist, estimations of Eqs. (39) and (40) using date of x_t as those of $x_{F,t}$ are in reality estimations of the following aggregate supply equations, respectively:

$$\pi_t = \varphi_2 x_{t|t-1} + \varepsilon_{2,t} = \varphi_2\left(x_{F,t|t-1} + x_{b,t|t-1}\right) + \varepsilon_{2,t} \tag{41}$$

and

$$\pi_t = a_3\pi_{t-1} + \varphi_3 x_{t|t-1} + \varepsilon_{3,t} = a_3\pi_{t|t-1} + \varphi_3\left(x_{F,t|t-1} + x_{b,t|t-1}\right) + \varepsilon_{3,t}\,, \tag{42}$$

where $x_{t|t-1}$ and $x_{b,t|t-1}$ are x_t and $x_{b,t}$ expected in period t–1, respectively. Although conceptually x_t = $x_{F,t}$ in the NKPC, in reality, inflation is a function of x_t (= $x_{F,t}$ + $x_{b,t}$) in estimation models of the pure NKPC and a function of lagged inflation and x_t (= $x_{F,t}$ + $x_{b,t}$) in hybrid NKPC models. Equations (41) and (42) are therefore actual estimation models of the pure NKPC and the hybrid NKPC, respectively. In the following discussion, Eq. (38) is referred to as Model 1, and Eqs. (41) and (42) are referred to as Models 2 and 3, respectively.

4.1.4. Superiority of model 1

In the sense that Model 1 is constructed on the basis of purely forward-looking micro-foundations of both trend inflation and friction, it is superior to Model 3 (hybrid NKPC), which lacks a micro-foundation for including lagged inflation. Model 2 (pure NKPC), however, does have a micro-foundation for the friction component, but it is usually empirically rejected, whereas the results of estimates from Model 3 are usually empirically accepted. Model 1 cannot be easily estimated empirically because it is difficult to distinguish between $x_{F,t}$ and $x_{b,t}$ in the data, but it is highly likely that Model 1 would be empirically supported because the trend inflation in Model 1 and the lagged inflation in Model 3 play almost the same role in the estimation of both models. Model 1 is therefore superior to Model 2 in the sense that it would most likely be empirically supported. As a whole, therefore, it is likely that Model 1 is the closest to the true mechanism of the three models.

4.2. Are frictions important?

4.2.1. Inappropriateness of the pure NKPC (Model 2)

Most empirical research has rejected Model 2, and the reason can be understood by comparing Model 2 with Model 1. If Model 1 is the true mechanism, Model 2 will be naturally rejected empirically because the movement of trend inflation (π_t^T) cannot be captured sufficiently only by x_t (= $x_{F,t}$ + $x_{b,t}$), as shown in Section 2. The estimates of φ_2 in Model 2 therefore will be always statistically non-significant as shown in many empirical researches. This result seems natural, because it is well known that inflation is persistent, and output gaps caused by frictions ($x_{F,t}$) cannot, by their nature, be persistent. Trend inflation, however, can be persistent. For these reasons, Model 1 is superior to Model 2.

4.2.2. A problem in hybrid NKPC (Model 3)

Unlike Model 2, Model 3 lacks a micro-foundation, but the results generated from the model match with empirical data. If Model 1 is the true mechanism, it is natural that the results from Model 3 would fit the empirical data. Suppose for simplicity that z_t = 2 in Eq. (2) because $\lim_{t\to\infty} z_t = 2$ as shown in Section 2. By Eq. (2),

$$\begin{aligned}\pi_t^T &= \pi_{t-1}^T + 6(\theta_G - \theta_P)\left[(t-\varpi)^2 - (t-\varpi-1)^2\right] \\ &= \pi_{t-1}^T + 6(\theta_G - \theta_P)[2(t-\varpi)+1] \end{aligned} \tag{43}$$

for $t \geq s$. Note that Eq. (1) indicates that the path of π_t^T just after a shift of θ_P is more complex than what is shown in Eq. (43) because π_t^T is influenced by its past path. Nevertheless, for simplicity, I assume that Eq. (43) holds even just after a shift in θ_P because $\lim_{t\to\infty} z_t = 2$, and the path of π_t^T will soon approach the path indicated in Eq. (43).

By combining Eq. (43) with Model 1,

$$\pi_t = \pi_{t-1} + \varphi_1\left(x_{F,t|t-1} - x_{F,t-1|t-2}\right) + \left(\varepsilon_{1,t} - \varepsilon_{1,t-1}\right) + 6a_1(\theta_G - \theta_P)[2(t-\varpi)+1] \tag{44}$$

Model 1 is transformed to be a function of lagged inflation (π_{t-1}); that is, Model 1 indicates that π_t is auto-correlated, as Model 3 also indicates. Model 3 includes lagged inflation without showing its micro-foundation, but Model 1 provides this micro-foundation and thus validates the inclusion of lagged inflation in an aggregate supply equation.

At the same time, however, Model 1 (Eq. 44) indicates that the coefficient of π_{t-1} should be unity. As is well known, estimates of a_3 in Model 3 are usually far less than unity (e.g., 0.5). The reason for the difference is that, although Models 1 and 3 are similar in that they include lagged inflation, other explanatory variables are not the same. The explanatory variables of π_t in Model 1 are $x_{F,t}$ and θ_P, and those in Model 3 are $x_{F,t}$ and $x_{b,t}$. Combining Model 3 with Eq. (44) (i.e., Model 1) yields

$$(1-a_3)\pi_{t-1}=\varphi_3(x_{F,t|t-1}+x_{b,t|t-1})+\varepsilon_{3,t}-\varphi_1(x_{F,t|t-1}-x_{F,t-1|t-2})-(\varepsilon_{1,t}-\varepsilon_{1,t-1})-6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]$$

Suppose for simplicity that $\varepsilon_{3,t}=\varepsilon_{1,t}=\varepsilon_{1,t-1}=0$ and $x_{F,t|t-1}-x_{F,t-1|t-2}=0$; thus,

$$(1-a_3)\pi_{t-1}+6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]=\varphi_3(x_{F,t|t-1}+x_{b,t|t-1})$$

should always hold. If a_3 = 1 as Model 1 indicates,

$$\varphi_3(x_{F,t|t-1}+x_{b,t|t-1})=6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]$$

should be always held. Both $\varphi_3(x_{F,t|t-1}+x_{b,t|t-1})$ and $6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]$ are negative, and thus estimates of Model 3 for a_3 = 1 can be statistically significant. However, even if a_3 < 1,

$$\varphi_3(x_{F,t|t-1}+x_{b,t|t-1})=(1-a_3)\pi_{t-1}+6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]$$

can be fallaciously satisfied if $(1-a_3)\pi_{t-1}+6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]<0$ and a larger value of φ_3 is given. In particular, when π_t is low, the probability that $(1-a_3)\pi_{t-1}+6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]$ is negative will be high, and the probability that a_3 is estimated to be far less than unity will be also high. In this case, the estimated value of φ_3 is fallaciously larger than the case of a_3 = 1. On the other hand, when π_t is high, a_3 will be estimated to be close to unity because $(1-a_3)\pi_{t-1}+6a_1(\theta_G-\theta_P)[2(t-\varpi)+1]$ is positive unless a_3 is close to unity. Even if a_3 is estimated to be far less than unity and statistically significant, therefore, Model 1 indicates that this is a fallacious result.

4.2.3. Frictions are less important than previously thought

In addition to erroneously small values of a_3, the fact that estimated values of φ_3 will be fallaciously larger is also important because it indicates that the influence of frictions (φ_3) will also be overestimated in Model 3. Furthermore, another factor influences the overestimation of frictions. φ_3 is the coefficient not of $x_{F,t}$ but of x_t (= $x_{F,t}$ + $x_{b,t}$); thus, φ_3 reflects not only frictions but also b_t. Model 1's micro-foundation indicates that the output gaps caused by time preference shifts ($x_{b,t}$) are irrelevant to the data generation mechanism of π_t. Equation (35) merely indicates that π_t is superficially correlated with $x_{b,t}$, but there is no causation between the two. Because φ_3 reflects both correlations between π_t and $x_{F,t}$ and π_t and $x_{b,t}$, the estimates of φ_3 will be influenced not only by frictions but also by the movement of b_t. With this effect, therefore, the influence of frictions, if it is measured by φ_3, will be overestimated.

The above two factors combined will greatly bias estimates of φ_3 upwards. It is likely therefore that the influence of frictions is largely overestimated if Model 3 is used for the evaluation. This finding has an important implication. Frictions have been regarded as an important factor in economic activities, but their role may be far smaller than has been previously thought. Even though some degree of frictions may actually exist and have real impacts, the results presented here indicate that the importance of frictions should not be exaggerated. Furthermore, this is most likely true not only for inflation but also for more general economic activities. This conclusion seems very natural, because it is highly likely that humans are sufficiently rational and can quickly and fully exploit the opportunities frictions provide and minimize the obstruction caused to economic activities by frictions.

4.3. Monetary policies

Monetary policies have usually been implemented on the basis of Model 2 or Model 3. If monetary policies were to be implemented on the basis of Model 1, then the effects could be different, so monetary policies based on Model 1 are examined in this section.

4.3.1. Aggregate demand equation

An examination of monetary policies requires not only an aggregate supply equation but also an aggregate demand equation. The following is a typical forward-looking New Keynesian aggregate demand equation (e.g., Clarida *et al*., 1999; Svensson and Woodford, 2003):

$$x_t = x_{t+1|t-1} - \beta_r \left(i_{t|t-1} - \pi_{t+1|t-1} - r \right) + \eta_t \tag{45}$$

where i_t is the nominal interest rate; r is the real interest rate at steady state; β_r is a constant coefficient; and η_t is an i.i.d. shock with zero mean. Equation (45) is obtained under the assumption that x_t is generated only by frictions. In other words, Eq. (45) assumes that $x_t = x_{F,t}$. However, in Model 1, $x_t = x_{F,t} + x_{b,t}$. Hence, to be consistent with Model 1, Eq. (45) should be changed to

$$x_{F,t} = x_{F,t+1|t-1} - \beta_r \left(i_{t|t-1} - \pi_{t+1|t-1} - r \right) + \eta_t \tag{46}$$

Therefore,

$$\ln\left[\exp\left(y_t\right) + b_t\right] - \tilde{y}_t = \ln\left[\exp\left(y_{t+1|t-1}\right) + b_{t+1|t-1}\right] - \tilde{y}_{t+1|t-1} - \beta_r \left(i_{t|t-1} - \pi_{t+1|t-1} - r \right) + \eta_t$$

and thus:

$$x_t = x_{t+1|t-1} + \left(x_{b,t} - x_{b,t+1|t-1} \right) - \beta_r \left(i_{t|t-1} - \pi_{t+1|t-1} - r \right) + \eta_t \tag{47}$$

Equation (47) indicates that x_t is influenced not only by $i_{t|t-1} - \pi_{t+1|t-1} - r$ but also by $x_{b,t} - x_{b,t+1|t-1}$. For example, when $\theta_{P,t}$ shifts upwards, $x_{b,t} - x_{b,t+1|t-1} < 0$ because $x_{b,t} < 0$, $x_{b,t+1|t-1} < 0$ and $\left| x_{b,t} \right| > \left| x_{b,t+1|t-1} \right|$; thus, x_t decreases by $\left| x_{b,t} - x_{b,t+1|t-1} \right|$ even if the effect of friction does not exist. Note that $x_{b,t}$ is an exogenous variable for the central bank.

4.3.2. Monetary policies

4.3.2.1. Utilizing frictions

Conventional monetary policy controls inflation and output gaps by utilizing frictions through the manipulation of nominal interest rates. However, Model 1 indicates that when economic fluctuations are caused by shifts in θ_P, inflation and output gaps are not necessarily controlled by conventional monetary policy because $x_{F,t}$ and $x_{b,t}$ are both generated. For example, when θ_P shifts downwards, $x_{b,t}$ increases and π_t^T also increases. The response of conventional monetary policy is to raise nominal interest rates to make $x_{F,t}$ decrease through Eq. (46) (the aggregate demand equation) and consequently make π_t decrease through the aggregate supply equation.

This conventional operation focuses only on $x_{F,t}$ and does not consider the effect of the shift of θ_P on π_t^T. Model 1, however, indicates that π_t depends on π_t^T, which is not affected by $x_{F,t}$. Hence, Model 1 indicates that π_t is not necessarily sufficiently controlled through the use of conventional monetary policy. To stabilize π_t by the conventional monetary policy, nominal interest rates should be raised far more than would be done with the conventional policy, at least up to the point where the effect of $x_{F,t}$ on

π_t overwhelms the effect of π_t^T on π_t. Even if nominal interest rates are raised to this far higher rate the π_t^T will accelerate unless θ_G is sufficiently reduced, as shown in Section 3. Nominal interest rates therefore should continue to be increased successively and indefinitely to stabilize inflation. Conversely, if θ_P has a large shift upward, the nominal interest rate will have to be reduced to zero (the lower bound of the nominal interest rate) unless θ_G is sufficiently increased. In this case, deflation will accelerate if θ_G is not sufficiently increased.

There is a great deal of evidence, however, that inflation has been stabilized by conventional monetary policy. I explore the possible reasons for this in the following sections.

4.3.2.2. Controlling the government's time preference

Although trend inflation π_t^T cannot be controlled by conventional monetary policy, it can be controlled through other types of monetary policy. The central bank can stabilize π_t^T by controlling the time preference rate of government (θ_G). As shown in Section 2, by manipulating nominal interest rates, the central bank can force the government to change θ_G. If θ_G changes according to the central bank's plan, then π_t^T will eventually stabilize. Model 1 indicates that, if π_t^T is stabilized at the target rate, π_t will also stabilize in the sense that π_t will not accelerate or decelerate and will remain near the target rate. For example, when θ_P shifts downwards and π_t^T begins to accelerate, the central bank should raise nominal interest rates and force the government to lower θ_G to stabilize the π_t^T. If θ_G is successfully lowered as planned then π_t^T will stabilize.

Section 2 shows that acceleration and deceleration of trend inflation are caused by the difference between θ_G and θ_P. Therefore, only monetary policy aimed at controlling the government's time preference rate can eventually stabilize inflation in the sense that π_t does not accelerate or decelerate. Conversely, the monetary policy of utilizing frictions plays only a minor role in the process of inflation stabilization.

4.3.2.3. Indistinguishable effects of monetary policies

The monetary policy of utilizing frictions (conventional monetary policy) nevertheless has been regarded as the main player in inflation stabilization because the tools used in both types of monetary policy (utilizing frictions and controlling θ_G) are the same. Both types of policy manipulate nominal interest rates. In addition, the directions of the effects of both policy types are the same; for example, if nominal interest rates are raised, inflation decreases. Hence, the effects of the two types of monetary policy are not easily distinguishable. Even if a central bank consciously implements a monetary policy of utilizing frictions, it automatically also implements the monetary policy of controlling θ_G at the same time. If inflation stabilizes as a result of the operation, the central bank may believe that the monetary policy of utilizing frictions was effective, even though it was the policy of controlling θ_G that was effective. This indistinguishable nature of the effects of the policy therefore will lead to the incorrect belief that the monetary policy of utilizing frictions is very effective for inflation stabilization even when θ_P shifts.

4.3.2.4. Power to control output gaps

The aggregate demand equation that is consistent with Model 1 (Eqs. 46 and 47) indicates another important nature of monetary policy. Monetary policies whether utilizing frictions or controlling θ_G, do not have enough power to stabilize output gaps. Because $x_{b,t}$ is exogenously given for the central bank, monetary policies cannot eliminate $x_{b,t}$. By decreasing $|x_{F,t}|$ through Eq. (46), $|x_t|$ becomes smaller to some extent, but a large $|x_t|$ will continue to exist because $x_{b,t}$ continues to exist. The results from Model 1 indicate that we should not expect to stabilize large output gaps through monetary policies, although small output gaps caused by frictions may be stabilized by them. In contrast, monetary policies—particularly the monetary policy of controlling θ_G —are very effective for stabilizing inflation.

Conclusion

Pure and hybrid NKPCs have been criticized for empirical failures and the lack of micro-foundation, respectively. An alternative approach to the Phillips curve is to focus on trend inflation. In this paper, a micro-foundation of trend inflation is shown. Another important factor in the Phillips curve is the nature of output gaps. In the NKPC, output gaps are assumed to be generated only by frictions, but in this paper another source of output gaps is considered. These output gaps are generated as a Nash equilibrium consisting of strategies of choosing a Pareto inefficient transition path of consumption to the steady state.

The model presented in this paper is superior to the hybrid NKPC because it is constructed on the basis of purely forward-looking micro-foundations of both trend inflation and friction, and it is superior to the pure NKPC in the sense that it can be empirically supported. Comparisons between the new model and both types of NKPC indicate that the role of frictions has been overestimated and that frictions are less important than previously thought. Even though some amount of frictions may actually exist, their importance should not be exaggerated.

The model also indicates that the conventional monetary policy of utilizing frictions cannot necessarily stabilize inflation. In contrast, the monetary policy of controlling θ_G is very effective. A problem is that the effects of both types of monetary policy are not distinguishable. This indistinguishable nature results in the incorrect belief that the monetary policy of utilizing frictions (conventional monetary policy) is very effective for inflation stabilization even when θ_P shifts.

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WHO CONTROLS INFLATION IN AUSTRIA?

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Abstract:

We model the rate of inflation and unemployment in Austria since the early 1960s within the Phillips/Fisher framework. The change in labor force is the driving force representing economic activity in the Phillips curve. For Austria, this macroeconomic variable was first tested as a predictor of inflation and unemployment in 2005 with the involved time series ended in 2003. Here we extend all series by nine new readings available since 2003 and re-estimate the previously estimated relationships between inflation, unemployment, and labor force. As before, a structural break is allowed in these relationships, which is related to numerous changes in definitions in the 1980s. The break year is estimated together with other model parameters by the Boundary Element Method with the LSQ fitting between observed and predicted integral curves. The precision of inflation prediction, as described by the root-mean-square (forecasting) error is by 20% to 70% better than that estimated by AR(1) model. The estimates of model forecasting error are available for those time series where the change in labor force leads by one (the GDP deflator) or two (CPI) years. For the whole period between 1965 and 2012 as well as for the intervals before and after the structural break (1986 for all inflation models) separately, our model is superior to the naïve forecasting, which in turn, is not worse than any other forecasting model. The level of statistical reliability and the predictive power of the link between inflation and labor force imply that the National Bank of Austria does not control inflation and unemployment beyond revisions to definitions. The labor force projection provided by Statistic Austria allows foreseeing inflation at a forty-year horizon: the rate of CPI inflation will hover around 1.3% and the GDP deflator will likely sink below zero between 2018 and 2034.

Keywords: inflation, unemployment, labor force, Phillips curve, forecasting, monetary policy, Austria.

JEL classification: E2, E3 E5.

1. Introduction

Price stability is a key responsibility of central banks. Following the Treaty on the Functioning of the European Union, the National Bank of Austria (Oesterreichische Nationalbank, OeNB) has established a quantitative definition of price stability, which is below but close to 2%. Monetary policy has to provide the target value, and thus, should be supported by an extensive analytical framework designed for decision-making process. Within this framework, economic analysis focuses on output and prices. The comprehension of driving force(s) behind the short-term fluctuations and the long-term evolution of price inflation and unemployment creates a solid basis for a sound monetary policy.

The literature on inflation in Austria is not as extensive as for the USA and chiefly belongs to the authors from the Austrian Institute of Economic Research (WIFO) (Baumgartner (2002)), the Institute for Advanced Studies (IHS) (Hofer and Koman (1991)), and the OeNB (Fritzer (2011) and Fritzer and all., (2008)). There are a few studies comparing inflation models developed by all three institutions (Ragacs and Schneider, (2007)). Considering the quality of data measured since the early 1950s and the accuracy of econometric modelling the Austrian economy deserves to be in the focus of professional attention of the broader economic community.

Two economic crises in the 21st century have significantly reshaped the set of tools for description and prediction of inflation in developed countries putting forward the concept of New Keynesian Phillips Curve (NKPC). Galí and Gertler (1999) formulated a quantitative model for "inflation expectations" controlled (or anchored) by various instruments of monetary and fiscal policy. This concept has placed central banks in focus of a comparative inflation study related to the differences in monetary policy and its results in developed countries (Gali, Gertler and Lopez-Salido (2001), Sims (2007)). Galí and Monacelli (2005) introduced the case of small open economies with terms of trade extending the original set of defining parameters, which was considered as the most relevant to the Austrian economy. However, Rumler (2007) and Mikhailov et all.(2008) modelled the inflation dynamics in small open economies using the NKPC and found just a moderate support to the terms of trade (external factor) as a driver of price inflation in Austria.

Kitov (2006) constructed a Phillips curve (PC) for Austria as a closed economy using the change in labor force as the only driver of inflation and unemployment. The modelling error for the period between 1965 and 2003 with a structural break near 1986 was smaller than that for any other structural model for the same period. The change in labor force explained 81% of the variability (R^2=0.81) in the rate of CPI inflation between 1965 and 2003 with the root-mean-square error (RMSE) for the best fit model of ~0.01 y^{-1} (1% per year). In this study, we extend the time series to 2012, revisit the original model, and validate it. Our results demonstrate that the OeNB hardly controls inflation and unemployment, but relies on the slow change in the workforce since the late 1990s.

Forecasting is an important part of economic analysis for the purposes of central banks. Rumler and Valderrama (2010) forecasted inflation using a single-equation NKPC and systematically compared their results to forecasts generated from a traditional Phillips Curve, a Bayesian VAR (which is also used for the first time to forecast Austrian inflation), a conventional VAR, an AR model and the naive forecast for 1-quarter, 4-quarters and 8-quarters. They found that the NKPC beats the forecasts derived from the time series models, the traditional PC, and the naive forecast in terms of lower RMSE only for longer forecast horizons of 1 and 2 years. The use of labor force as the driving force of inflation (Kitov and Kitov (2010)) converts inflation forecasting into labor force projection. Then, the short-term (a few months) inflation forecasts might be spoiled by noisy data from labor force surveys and CPI estimates, but the mid- and long-term projections of working age population and labor force participation models are able to accurately predict the evolution of prices treated as "inflation expectations" in the NKPC models.

The remainder of this paper consists of two sections and conclusion. Section 2 briefs on major developments within the Phillips curve framework, introduces a set of linear and lagged relationships between studied parameters, and describes the Boundary Element Method used to estimate coefficients in these relationships. Section 3 presents a series of revised inflation and unemployment models for Austria and reports some quantitative/statistical results for two individual and the generalized link between labor force, inflation, and unemployment.

2. The Fisher/Phillips curve framework

Irving Fisher (1926) introduced price inflation as driving the rate of unemployment. He modelled monthly data between 1915 and 1925 using inflation lags up to five months. The inflation and unemployment time series were short and contained higher measurement errors to produce robust statistical estimates of coefficients and lags in the relevant causal relationship. Kitov (2009) estimated a Fisher-style relationship for the USA using observations between 1965 and 2008 and found that the change in unemployment lags behind the change in inflation by 10 quarters. The 43-year period provides good resolution and high statistical reliability of both regression coefficients and the lag. This relationship was successfully tested for co-integration and Granger causality. The two-and-a-half year lag implies the only order of occurrence. But other countries may demonstrate different lags and order (Kitov and Kitov (2010)).

Phillips (1958) interpreted the link between (wage) inflation and unemployment in the UK in the opposite direction. The original Phillips curve implied a causal and nonlinear link between the rate of change of the nominal wage rate and the contemporary rate of unemployment. He suggested that wages are driven by the change in unemployment rate. The assumption of a causal link worked well for some periods in the UK. When applied to inflation and unemployment measurements in the USA, the PC successfully explained the 1950s. Then, the PC became an indispensable part of macroeconomics which has been extensively used by central banks ever since. The success of the PC did not last long, however, and new data measured in the late 1960s and early 1970 challenged the original version. When modelling inflation and unemployment in Austria, we follow up the original assumption of a causal link between inflation and unemployment to construct an empirical Fisher/Phillips-style curve.

The period of fast inflation growth in the late 1960s and 1970s brought significant changes to the original PC concept. The mainstream theory had to include autoregressive properties of inflation and unemployment in order to explain the observations. For the sake of quantitative precision, the rate of unemployment was replaced by different parameters of economic and financial activity. All in all, the underlying assumption of a causal link between inflation and unemployment was abandoned and replaced by the hypothesis of “rational expectations” (Lucas (1972), Lucas (1973)), and later by the concept of “inflation expectations” (Galí and Gertler (1999)). The former approach includes a varying number of past inflation values (autoregressive terms). It was designed to explain inflation persistency during the high-inflation period started in the early 1970s and ended in the mid 1980’s.

The concept of inflation expectations surfaced in the late 1990s in order to explain the Great Moderation (Clarida, Galí and Gertler (2000), Cecchetti, Flores-Lagunes and Krause (2004), Bernanke (2004)) as controlled by monetary and fiscal authorities (Sims (2007), Sims (2008)). The term “New Keynesian Phillips Curve” was introduced in order to bridge this new approach to the original Keynesian framework (Gordon (2009)). The number of defining parameters has dramatically increased in the NKPC (a few autoregressive terms with varying coefficients) relative to the parsimonious Phillips curve. However, both approaches have not been successful in quantitative explanation and prediction of inflation and/or unemployment (Rudd and Whelan (2005a), Rudd and Whelan (2005b)).

Stock and Watson (1999) were outspoken on data and tested a large number of Phillips-curve-based models for predictive power using various parameters of activity (individually and in aggregated form) instead of and together with unemployment. This purely econometric approach did not include extended economic speculations and was aimed at finding technically appropriate predictors. The principal component analysis (Stock and Watson (2002)) was a natural extension to the multi-predictor models and practically ignored any theoretical background. Under the principal component approach, the driving forces of inflation are essentially hidden.

The original Phillips curve for the UK and the Fisher curve, which could be named as an “anti-Phillips curve”, both provide solid evidences for the existence of a causal link between inflation and unemployment. The conflict between the directions of causation can be resolved when both variables are driven by a third force with different lags. Depending on which lag is larger inflation may lag behind or lead unemployment. Co-movement found in Japan is just a degenerate case (Kitov and Kitov (2010)).

The framework of our study is similar to that introduced and then developed by Stock and Watson (2006, 2007, 2008) for many predictors. They assessed the performance of inflation forecasting in various specifications of the Phillips curve. Their study was forced by the superior forecasting result of a univariate model (naïve prediction) demonstrated by Atkeson and Ohanian (2001). Stock and Watson convincingly demonstrated that neither before the 2007 crisis (Stock and Watson (2007)) nor after the crisis (Atkeson and Ohanian (2001)) can the Phillips curve specifications provide long term improvement on the naïve prediction at a one-year horizon.

Following Fisher and Phillips, we do not include autoregressive components in the Phillips curve and estimate two different specifications for inflation:

$\pi t) = \alpha + \beta u(t\text{-}t_0) + \varepsilon(t)$ (1)

$\pi t) = \alpha_1 + \beta_1 l(t\text{-}t_1) + \varepsilon_1(t)$ (2)

where $\pi t)$ is the rate of price inflation at time t, α and β are empirical coefficients of the Phillips curve with the time lag t_0, which can be positive or negative, $u(t)$ is the rate of unemployment, and $\varepsilon(t)$ is the error term, which we minimize by the least squares (LSQ) method applied to the cumulative curves, with the initial and final levels fixed to the observed ones. In (2), $l(t)=dlnLF(t)/dt$ is the rate of change in labor force, α_1 and β_1 are empirical coefficients of the link between inflation and labor force, t_1 is the non-negative time lag of inflation, and $\varepsilon_1(t)$ is the model residual. Then, we represent unemployment as a linear and lagged function of the change rate in labor force:

$u(t) = \alpha_2 + \beta_2 l(t\text{-}t_2) + \varepsilon_2(t)$ (3)

with the same meaning of the coefficients and the lag as in (2). We finalize the set of causal models with a generalized version:

$\pi(t) = \alpha_3 + \beta_3 l(t\text{-}t_1) + \gamma_3 u(t\text{-}t_0) + \varepsilon_3(t)$ (4)

Eqs. (2) through (4) have been re-estimated with the data for the past nine years and the Boundary Element Method (BEM) instead of standard regression.

The BEM converts linear (also partial) differential equations, *e.g.* relationships (2) through (4), to a set of integral equations. The solution of the integral equations for the period between t_0 and t_{01} is an exact solution of the original differential equations. For (2):

$$\int_{\tau_0}^{\tau_{01}} d[\ln P(t)] = \int_{\tau_0}^{\tau_{01}} \beta_1 d[\ln LF(\tau)] + \int_{\tau_0}^{\tau_{01}} \alpha_1 d\tau + \int_{\tau_0}^{\tau_{01}} \varepsilon_1(\tau) d\tau] \quad (5)$$

where $\pi t)$ is by the rate of change in the price level, $P(t)$, and $\tau = t - t_1$ and $\int_{t_0}^{t_{01}} \varepsilon_1(\tau) d\tau = 0$ The solution of the integral Eq. (5) is as follows:

$$\ln P\Big|_{t_0}^{t_{01}} = \beta_1 \ln LF\Big|_{\tau_0}^{\tau_{01}} + \alpha_1 t\Big|_{\tau_0}^{\tau_{01}} + C \quad (6)$$

where C is the free term, which has to be determined together with coefficients α_1 and β_1 from the boundary conditions: $P(t_0)=P_0$, $P(t_{01})=P_1$, $LF(\tau_0) = LF_0$ and $LF(\tau_{01}) = LF_1$. For 1-D problems, we have fixed values as boundary conditions instead of boundary integrals. The number of boundary conditions in (6) is complete for calculation (or quantitative estimation, if there is no analytic solution) of all involved coefficients. Without loss of generality, one can always set P_0=1.0 as a boundary condition. The estimated coefficients α_1*, β_1*, and C* entirely define the particular solution of (6):

$$\ln[P(t_{01})] = \beta_1^* \ln[LF(\tau_0)/LF(\tau_{01})] + \alpha_1^*(\tau_{01} - \tau_0) \quad (7)$$

at t_{01}, as well as over the entire time interval between t_0 and t_{01}. It is presumed that $LF(t)$ is a discrete function known from measurements.

The estimation of all involved coefficients gives numerical solutions of 2-D and 3-D problems by the BEM in scientific and engineering applications. In this study, the least-square method is used to estimate the best fir coefficients. Therefore, the residual between observed and predicted curves is minimized in the L2 metrics. For solving problem (7) with an increasing accuracy, one can run over a series of boundary conditions for subsequent years.

In terms of the boundary elements method, the right hand side of (7) is the particular solution of the (ordinary) differential equation (2). Since $t_1 \geq 0$, the causality principle holds, and the independent function is known before the dependent one. The only principal difference with the standard BEM used in scientific applications is that the solution (7) is not a closed-form or an analytic solution. The solution is the change in labor force in a given country, which may follow a quite exotic trajectory as related to demographic, social, economic, cultural, climatic, etc. circumstances. From (7), inflation can be exactly predicted at a time horizon t_1 and foreseen at longer horizons with various projections of labor force.

In (7), a linear combination of $ln[(LF(t)/LF(t_0))]$ and $(t-t_0)$ defines any particular solution of (2). The rate of price inflation may change only due to the change in labor force. However, the overall price level may grow even when workforce is constant because of $\alpha_1(\tau_{01}-\tau_0)$ term, for $\alpha_1 \neq 0$.

3. Inflation and unemployment models

In terms of working age population, Austria represents an example of a small economy. The Austrian economy has a long history of measurements with open access to all time series and descriptive information. Essentially, the data quality is high. It is the most important characteristic defining the success of any quantitative modelling. We distinguish two main sources of uncertainty related to the data. One source is associated with measurement errors. Due to limited population coverage, the accuracy of labor force surveys is low. Therefore, the original annual figures for unemployment and labor force are not precise. In labor surveys, the measurement accuracy depends on sampling and non-sampling errors. The former is estimated from the population coverage and standard statistical procedures, and the latter is more difficult to evaluate.

Another source of quantitative uncertainty is important for both labor force and inflation measurements. It is associated with the revisions to definitions. In many cases, these revisions are significant, as one can judge from the description given by the OECD (2013). When applied to labor force, the definitional revisions introduce artificial breaks (jumps) in time series as associated with the change in units of measurements. European countries have implemented these revisions at different times creating asynchronous breaks. Some modifications of methodologies and procedures related to inflation measurements are accompanied by the introduction of new measures such as harmonized index of consumer prices (Eurostat (2013)). This index includes rural consumers, but excludes the imputed rent components. It replaced the old CPI definition in the official statistics.

We use six independent sources providing annual readings of CPI, GDP deflator, population estimates, unemployment rate, participation rate, and labor force level: Eurostat, OECD, AMS (Arbeitsmarktservice) Österreich (http://www.ams.or.at), HSV (Hauptverband der Sozialversicherungtraeger) Österreich (http://www.hsv.or.at), Statistik Austria (SA - http://www.statistik.at), and the Österreichische Nationalbank (ÖNB – http://www.oenb.at). These sources estimate the same variables in different ways. Comparison of formally equivalent time series allows quantitative evaluation of the differences between them. The cross-examination has two main purposes. Firstly, it demonstrates the discrepancy between these series as a quantitative measure of the uncertainty in corresponding parameters. Secondly, we determine the degree of similarity (cross correlation) between these series in order to assess the performance of some true time series, which represent actual values of measured parameters according to perfect definitions.

Data uncertainty puts a strong constraint on the level of confidence related to statistical estimates. One cannot trust statistical inferences with a confidence level higher than that allowed by the intrinsic data uncertainty. On the other hand, equivalent time series obtained according to various definitions (procedures, methodologies, samples, etc.) of the same parameter represent different proportions of the true value for a given parameter. For example, various definitions of employment are aimed at obtaining the number of persons who work for pay or profit, but the minimum level of payment may differ across definitions.

Several definitions are designed to approach the (virtual) true value. If consistent and successful, these definitions may provide estimates, which describe the same portion of the true values over time.

Therefore, these successful estimates are scalable - one can easily compute values according to all definitions having only one of them and relevant conversion factors. In that sense, various definitions (and related estimates) should be interchangeable when used to model the link between inflation, unemployment, and labor force.

Five different time series of price inflation, constructed with the use of varying definitions, are presented in Figure 1: CPI and GDP deflator (DGDP) as obtained using prices expressed in national currency (national accounts - NAC), and the GDP deflator estimated using the Austrian shilling/Euro exchange rate before the introduction of Euro. The latter variable is characterized by the largest variations. Two curves representing the NAC CPI and NAC GDP deflator are closer, correlation coefficient (*R*) of 0.91 for the period between 1961 and 2012, but differ in amplitude and timing of principal changes. There are periods of almost total agreement, however. The Euro GDP deflator series is characterized by correlation coefficients of 0.81 and 0.80 as obtained for the NAC DGDP deflator and CPI, respectively. Therefore, we can expect a better interchangeability between the NAC CPI and NAC GDP deflator than that in the other two possible combinations. Finally, the NAC and OECD CPI estimates are almost identical: *R*=0.9997. Since the mid-1970s, the rate of price inflation in Austria has a definition-independent tendency to decrease.

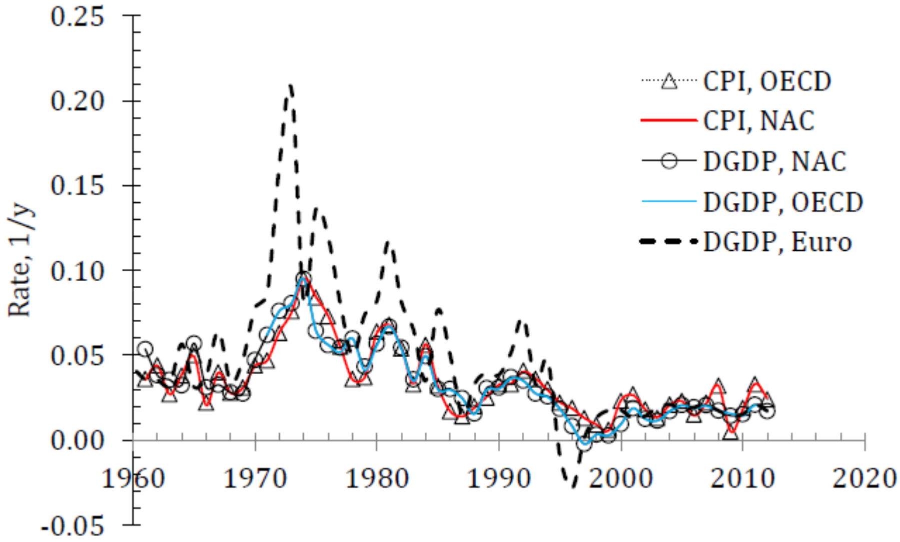

Figure 1. Comparison of five variables representing inflation in Austria

Regarding time incompatibility in the inflation time series, Rumler and Valderrama (2010) mentioned a possibility of a structural break at the end of the 1980s in the inflation data used for the estimation of a Phillips curve for Austria. They reported the absence of statistical evidence of a structural break at any later date in Austria. Mikhailov *et al.* (2008) fixed a break in Austrian economic data to 1991 due to its close economic links with Germany.

In Europe, labor force surveys generally cover small portions of the total population. The levels of labor force and unemployment are estimated using specific weights (population controls) for every person in a given survey to compute the proportion of population with the same characteristics. The population controls in predefined age-sex-race bins are primarily obtained during censuses, which cover the entire population. Between censuses, the population controls are obtained by the population components change: births, deaths, and net migration.

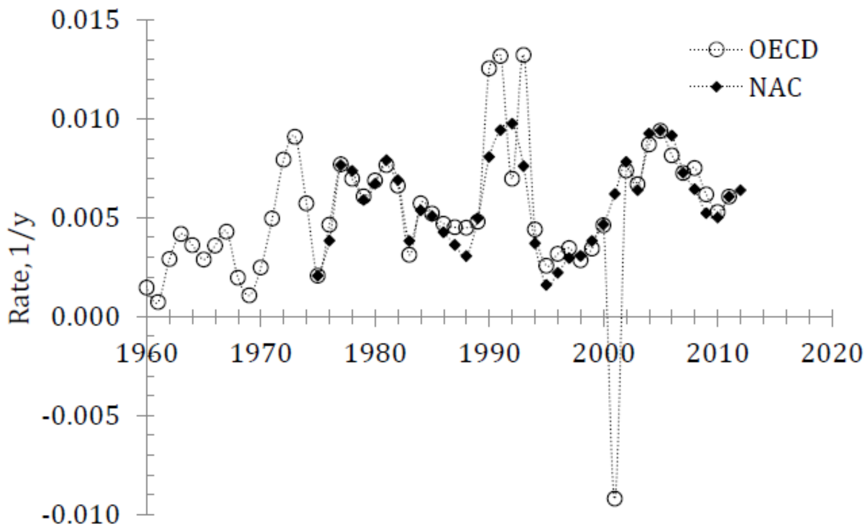

Figure 2. Comparison of the rate of change in working age population (aged 15 and over) as determined by the OECD and national statistics (NAC)

Later revisions to population estimates sometimes reach several percent. Thus, when using current figures of labor force and unemployment, one has to bear in mind that they are subject to further revisions. Figure 2 illustrates the differences in population estimates between the OECD and Statistik Austria (NAC): two curves represent the rate of change in the population of 15 years of age and over. Between 1960 and 1983, the curves coincide since the OECD uses the national definition. After 1983, the curves diverge. There are three distinct peaks in the OECD curve: between 1990 and 1993 and in 2002, which are related to the population revisions. As explained by the OECD (2005) for the population series:

Series Breaks. *From 1992, data are annual averages. Prior to 1992, data are mid-year estimates obtained by averaging official estimates at 31 December for two consecutive year ... From 2002, data are in line with the 2001 census.*

The 2002 revision completely compensates the difference between the OECD and Statistik Austria as accumulated during the previous 20 years: the populations in 1982 and 2002 coincide. Such step adjustments are observed in the USA population data as well. These jumps significantly deteriorate any statistical estimates, but can be completely removed when evenly redistributed over the previous period. Sometimes step adjustments are confused with actual changes in economic variables. One has to be careful in distinguishing between genuine changes and artificial corrections usually associated with the years of census or significant revisions to definitions.

The national estimates in Figure 2 are visually smoother indicating some measures applied to distribute the errors of the closure and other adjustments over the entire period. On average, the population over 15 years of age in Austria has been changing slowly so far – at an annual rate below 0.5% - with a few spikes to the levels of 0.7% to 1.0%. This slow but steady growth supports the gradual increase in labor force.

The rate of labor force growth was low in Austria during the past 15 years, as Figure 3 depicts. Two time series estimated by the OECD and NAC describe the change in labor force. The NAC readings include the estimates of employment made according to the HSV definition and the reports on unemployment made by the AMS. Both agencies base their estimates on administrative records. Thus, their approach has been undergoing weaker changes in definitions and procedures since the 1960s compared to that adopted by the OECD.

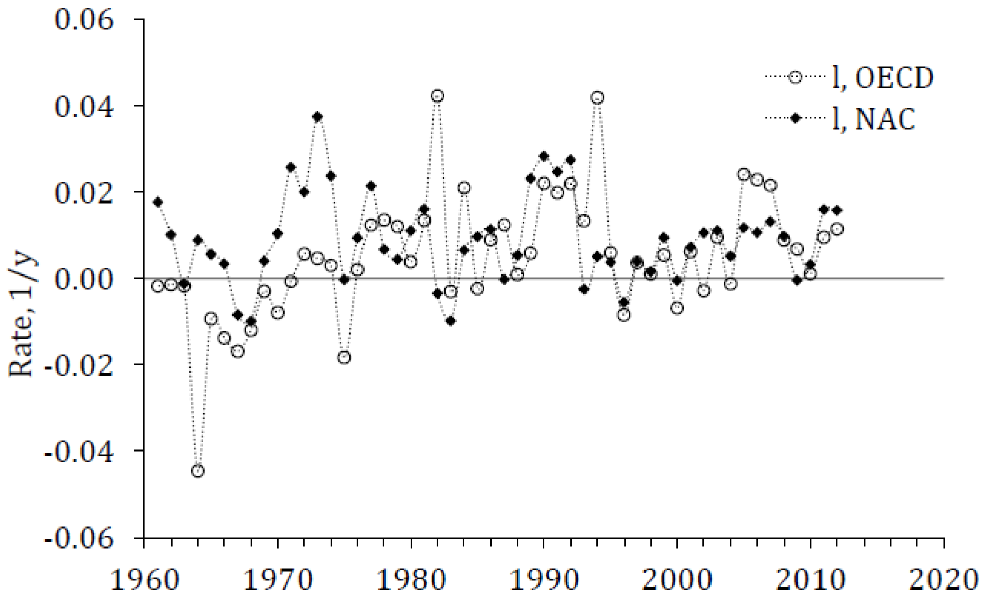

Figure 3. Comparison of the change rate of labor force, as reported by the OECD and NAC

The curves in Figure 3 inherit the features, which are demonstrated by corresponding working age populations in Figure 2. The OECD curve is characterized by several spikes of artificial character. The NAC curve is smoother. It demonstrates a period of slow growth with high volatility in the late 1970s, a period with an elevated growth rate with high volatility between 1981 and 1995, and again a slow growth period with low volatility during the years from 1995 to 2012. The second period is characterized by significant changes in the labor force definition - both for employment and unemployment (OECD, 2013):

<u>Series breaks.</u> In 1982, re-weighting of the sample was made, due to an underestimation of persons aged 15 to 29 years. In 1984, the sample was revised and a change occurred in the classification of women on maternity leave: they were classified as unemployed before 1984 and as employed thereafter. In 1987, a change occurred in the definition of the unemployed where non-registered jobseekers were classified as unemployed if they had been seeking work in the last four weeks and if they were available for work within four weeks. In previous surveys, the unemployment concept excluded most unemployed persons not previously employed and most persons re-entering the labor market. Employment data from 1994 are compatible with ILO guidelines and the time criterion applied to classify persons as employed is reduced to 1 hour.

Therefore, one can expect some changes in the units of labor force measurements during the period between 1982 and 1987 as well as in 1994. The latter change is potentially the largest since the time criterion dropped from 13 hours, as had been defined in 1974, to 1 hour. For the sake of consistency in definitions and procedures, the AMS labor force is used as an independent variable. The OECD labor force is also used in a few cases to illustrate that both definitions provide similar results.

The AMS time series of change rate of labor force contains 62 readings between 1951 and 2012. Here, only the period after 1960 is analyzed and we use 52 readings after 1961 to test for unit roots. This is the first time series we test for stationarity because it is used as a predictor. The inflation time series are likely biased by many revisions to definitions during the modelled period. We discuss unit root tests in the inflation series within the framework of the link between inflation and labor force. The null hypothesis of a unit root in the AMS time series was rejected by the ADF test is -4.22, with 1% critical value of -3.58). For the OECD series, the ADF test is -4.72. The Phillips-Perron test has also rejected the null of a unit root in both series. For the AMS series: $z(\rho)$=-26.79 (-18.94) and $z(t)$=-4.18 (-3.58); for the OECD: $z(\rho)$=-33.82 and $z(t)$=-4.81. Hence, both time series of the change rate of labor force are stationary or I(0) processes.

There are three time series associated with unemployment in Austria shown in Figure 4, as defined by national statistics approach (AMS), Eurostat, and the OECD. It is illustrative to trace the definitional changes. Currently, the OECD and Eurostat use very similar approaches. There was a period between 1977 and 1983 when the OECD adopted the national definition, which was different from the one used by Eurostat. During a short period between 1973 and 1977, all series were very close. Major changes occurred between 1982 and 1987. The unemployment curves in Figure 4 are characterized by two distinct branches: a low (~2%) unemployment period between 1960 and 1982 and a period of higher unemployment (~4% for the OECD and Eurostat, and ~6.5% for the AMS) since 1983. These switches between various definitions present additional obstacles to obtaining a unique relationship between labor force and unemployment. The AMS definition is based on administrative records and might be the most consistent among the three, However, this definition differs from the one recommended by the International Labor Organization. Since all unemployment time series contain two distinct segments with a big step between them it is hardly stationary. Formally, all tests did not reject the null of a unit root due to the artificial structural break between 1982 and 1987. When corrected for this step, the rate of unemployment should be stationary.

The above discussion explains why one cannot model unemployment over the whole period by a unique linear relationship. There was a period of substantial changes in units of measurement between 1982 and 1987. Therefore, we model the rate of unemployment during the periods before 1982 and after 1986 separately. The period between 1982 and 1987 is hardly to be matched by a linear relationship. Results of the modelling are presented in Figure 5, where the AMS unemployment curve is matched by the following relationships:

$$u(t) = 0.35l(t) + 0.0260; \; t<1982$$
$$u(t) = 0.70l(t) + 0.0705; \; t>1986 \quad (8)$$

The NAC labor force without a time lag is used to predict unemployment using equation (8). The absence of a lag might be presumed as natural behavior of labor force and unemployment, as one of the labor force components. All empirical coefficients in (5) provide the best fit between the observed and predicted curves. From this Figure and relationship, one can conclude that there was a step change in the average level of unemployment from approximately 0.03 during the years before 1982 to 0.07 for the period after 1986. Accordingly, the slope doubled in 1987 indicating higher sensitivity of unemployment to the change in labor force under new definitions introduced between 1982 and 1987.

The estimate of root-mean-square error (RMSE) obtained for the OECD unemployment time series in Austria during the period between 1983 and 2012 is 0.0054. Therefore, the inherent variation in this data series is extremely low and thus difficult to model. Not surprisingly, the standard deviation for the model error in (8) is 0.0055. This relationship is accurate but unreliable.

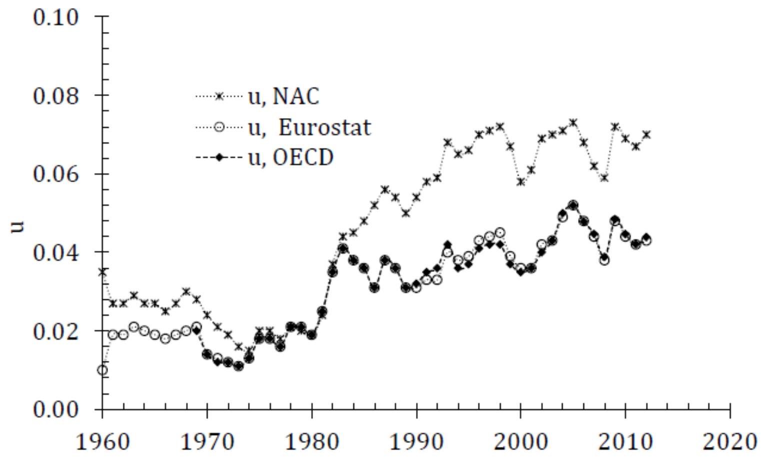

Figure 4. Estimates of unemployment rate in Austria according to definitions given by the AMS, Eurostat, and the OECD

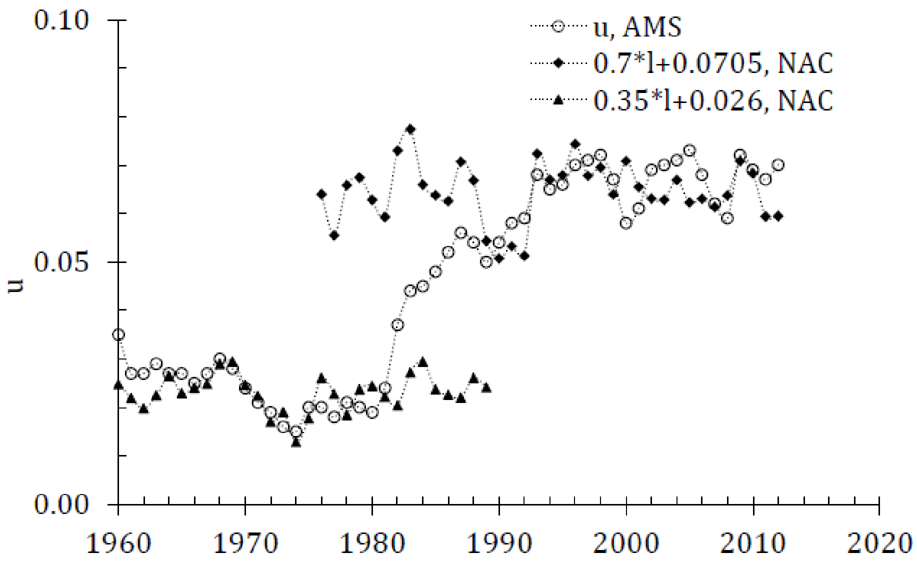

Figure 5. Comparison of the observed (AMS) unemployment rate and that predicted from the NAC (AMS+HSV) labor force.

The changes in the unemployment and labor force definitions between 1983 and 1987 make it impossible to fit the unemployment curve during this period

Figure 6 depicts the observed and predicted, annual and cumulative, rates of price inflation in Austria for the period between 1960 and 2012. The inflation time series is represented by the GDP deflator determined by Eurostat: all prices are converted in Euro before 2001. As mentioned above, there was a significant definitional and procedural change in the labor force (employment and unemployment separately) surveys in the 1980s. To compensate the effect of the artificial change in measurement units we introduced a structural break in our model. Two periods are described by two different linear relationships between the dependent and independent variables. The labor force is taken according to the AMS definition. Two relationships predicting inflation are as follows:

$$\pi(t) = 3.846l(t-0) + 0.0484; \qquad 1965 \le t \le 1986$$

(0.67) (0.009) (9)

$$\pi(t) = 2.383l(t-0) + 0.00021; \qquad t \ge 1987$$

(0.33) (0.004)

The estimates of coefficients and lag (0 years) in (9) were obtained altogether by the Boundary Element Method (BEM) with the least-square fitting between the integral curves over the entire period, with 1986 being the point of structural break. The break point has been also estimated by the fitting procedure. If the model residual for the integral variables is an I(0) process then they are co-integrated and the annual model error is an I(-1) process. All estimated slopes are reliable with p-values less than 10^{-3}. Since all readings in both time series in (9) have non-zero uncertainties the linear regression technique would underestimate the slopes. If to use the coefficients obtained by linear regression, the cumulative curves in Figure 6 would diverge. By design, the BEM guarantees perfect convergence between integral solutions, and thus, between the annual measurements.

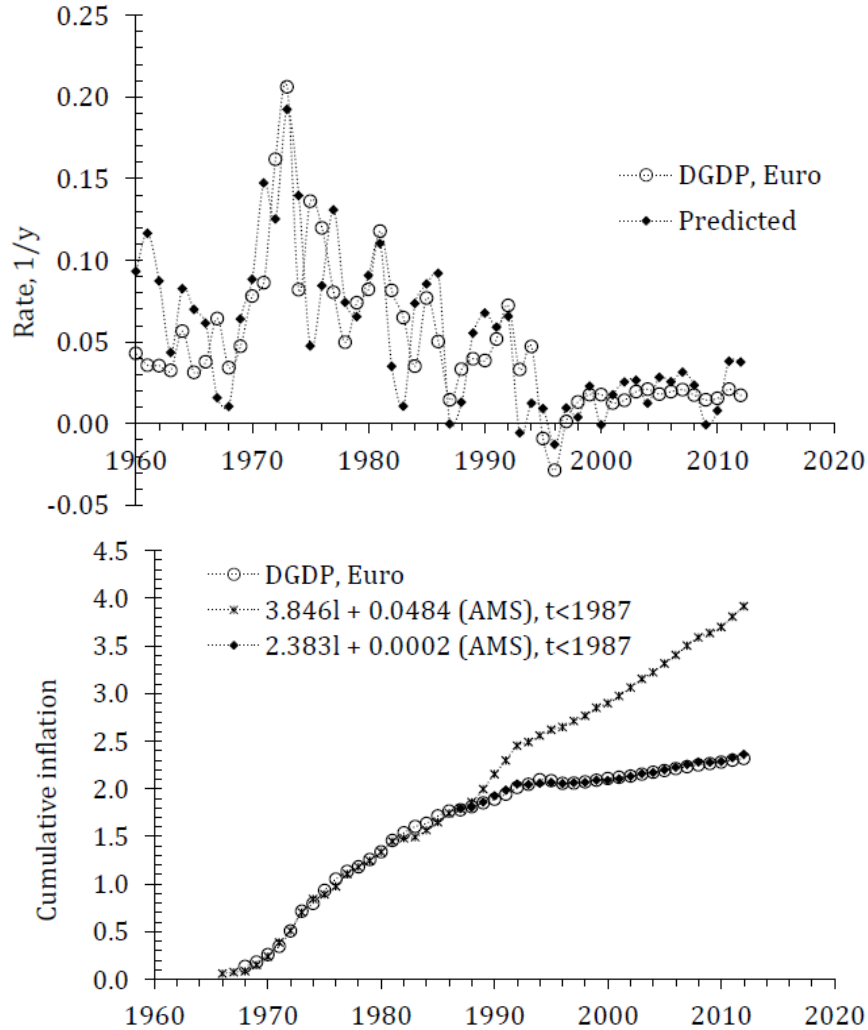

Figure 6. Comparison of the observed (DGDP, Euro) and predicted inflation in Austria.
The upper panel displays annual readings and the lower one – cumulative inflation since 1965. The periods before and after 1986 are described separately. In order to demonstrate the effect of structural break the earlier relationship is extended beyond 1986

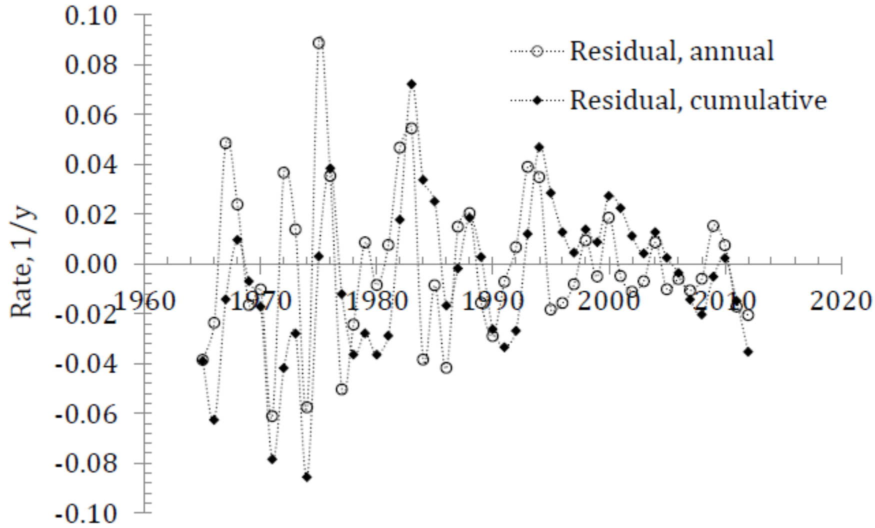

Figure 7. Model errors for the annual and cumulative curves in Figure 6.

For (9), the BEM seeks to minimize the RMS cumulative error over the entire period. If the model error for integral variables is an I(0) process then the annual model error is an I(-1) process

In the original DGDP Euro time series, the average values is 0.049 and standard deviation σ=0.044. The model residual (see Figure 7) is characterized by RMSE=0.026. The naive forecasting technique (AR(1) model) provides RMFSE=0.032 for the residual time series, i.e. the first difference of the original DGDP series. Therefore, the model based on the change in labor force without autoregressive terms definitely outperforms the naive forecasting for the whole period. (We assume that the level of labor force can be accurately estimated one year ahead). Our model retains the same functional (linear) link between the studied variables, which is perfectly parsimonious.

Relations (9) also outperform the naive forecasts in both periods taken separately. After 1986, RMSE=0.014 which is lower than 0.019 for the AR(1) model. The DGDP time series is characterized by σ=0.020 for this period. Between 1965 and 1986, the estimated standard deviations are 0.036, 0.043, and 0.043, respectively. The coefficient of determination R^2=0.66 for the entire period, i.e. the change in labor force explains 66 % of the DGDP variability. For the cumulative curves in Figure 6, RMSE=0.030 (marginally higher than for the annual model error), R^2=0.999.

Since the cumulative curves are both non-stationary, I(1), processes we tested them for co-integration. The Johansen test showed the maximum rank 1, i.e. the existence of one long-term equilibrium relation between the cumulative curves. (The trace statistic is 0.214* with the 5% critical value 3.84.) The null hypothesis of a unit root in the residual time series (the difference between the cumulative curves) was rejected by the Augmented Dickey-Fuller test (-3.74, with 1% critical value of -3.60). The Phillips-Perron test has also rejected the null of a unit root: z(ρ)=-20.91 (-18.70) and z(t)=-3.67 (-3.60). Formally, the observed and predicted cumulative time series are co-integrated, and thus, the extremely high coefficient of determination is not biased.

With the unbiased coefficient of determination of 0.999, one can interpret the relation between the cumulative curves as a causal link. The level of labor force is controlled by the size of working age population and the rate of participation in labor force. The former variable depends on the integral value of births 15 and more years ago, total deaths in working age population, and net migration. All these processes are far beyond the influence of price inflation. The rate of participation in labor force is rather a slow evolving variable and depends on economic activity. Hence, the cumulative price inflation cannot affect the net change in labor force, i.e. the cumulative change in labor force in (9). On the other hand, the change in labor force explains 99.9% of variability in the cumulative inflation. One can substitute the price change with labor change during the same period.

The slope ratio in (9) is 3.84/2.38 ~ 1.61 and the intercept dropped from 0.0484 to zero. The change in the slopes is consistent with the changes in definition of labor force between 1982 and 1987 – gradually more and more persons were counted in as employed and unemployed with a substantial increase in the labor force level. This increase resulted in the growth of annual increments and the decrease of the slope (or sensitivity) in (9). Therefore, the inflation sensitivity to the new measures of labor force, or new units of measurement, in Austria decreased in 1987. When the relationship obtained for the first period is used for the second period, the rate of inflation is significantly overestimated, as shown in the lower panel of Figure 6. The deviation between the two predicted curves after 1986 clearly demonstrates the influence of the changes in measurement definitions for quantitative modelling of economic parameters.

The predicted curves are in good agreement with actual inflation. A prominent feature is the overall similarity between 1968 and 1975, when the highest changes in the inflation rate were observed: from 0.034 in 1968 to 0.21 (21% per year) in 1973, and back to 0.05 in 1978. Overall, the Phillips curve, the NKPC or any other model that rely on autoregressive properties of inflation fail to describe this kind of dynamics. Due to the LSQ fitting, the model coefficients and lags are adjusted to the biggest changes, i.e. to the peak in 1973. However, Figure 1 shows that two other measures of inflation have peak values at different times.

Our model fully relies on labor force estimates. Several simple measures have been proposed in order to improve the quality of labor force measurements and to obtain more reliable statistical estimates. Due to lack of information on quantitative characteristics of the revisions applied to the Austrian labor force series we cannot explicitly correct for possible step revisions. In the absence of correcting measurements, it is natural to apply the moving average technique. Three-year moving average, MA(3), suppresses the noise associated with the labor force measurements and also removes the half-year shift in timing between inflation and labor force readings. In the lower panel of Figure 8, the MA(3) smoothed predicted and observed curves are shown in order to demonstrate the accuracy of the predictions when longer bases are used to estimate inflation and labor force. The only period of larger deviations between these curves is from 1984 to 1986, i.e. near the structural break.

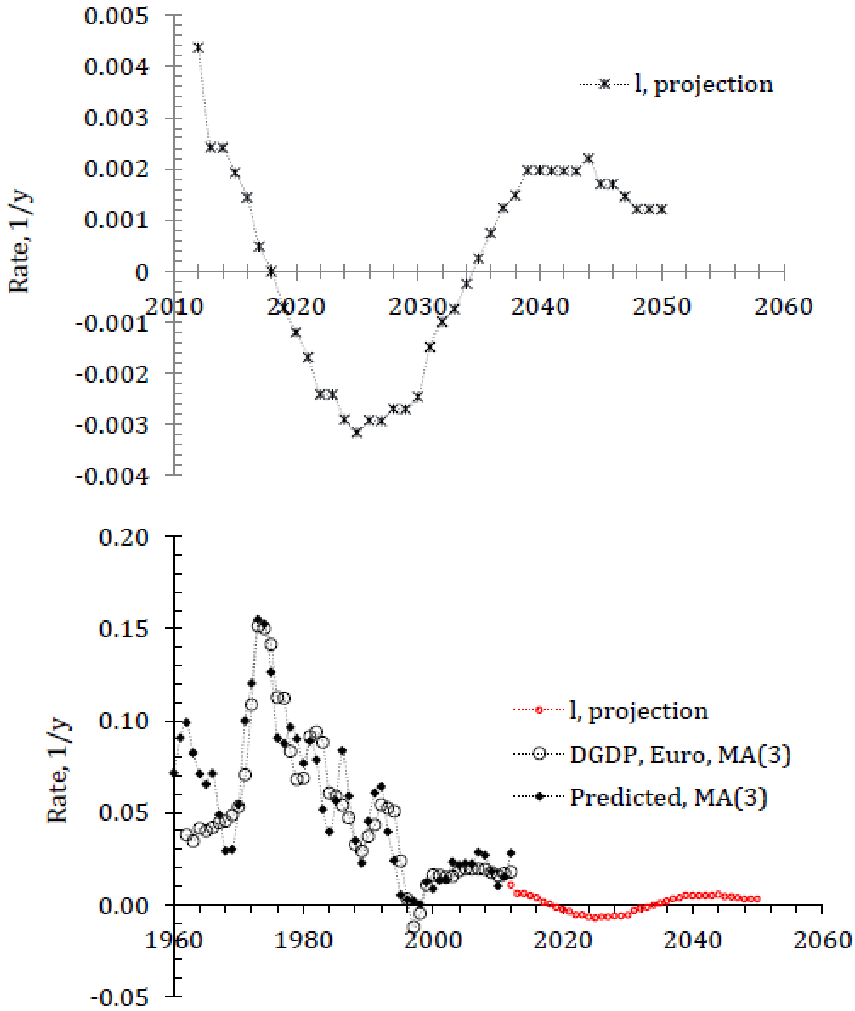

Figure 8. Upper panel: Labor force projection borrowed from Statistik Austria.
The period from 2018 to 2034 is characterized by a negative growth rate. Lower panel: Inflation projection obtained from the labor force projection according to (9). The measured and predicted curves between 1960 and 2012 are smoothed with MA(3) in order to demonstrate the accuracy of the predictions when longer bases are used to estimate inflation and labor force

The upper panel of Figure 8 depicts the change rate of labor force from 2011 to 2050, as obtained from a projection published by Statistik Austria (2013). Not considering the accuracy and reliability of the 40-year-ahead projection we focus on the overall behavior of inflation during the same period. In the lower panel, the GDP deflator projection obtained by (6) from the labor force projection.

Since the intercept in (9) after 1986 is practically zero, the negative rate of labor force is equivalent to deflation. Therefore, from 2018 to 2034 a deflationary period is expected as related to the GDP deflator.

Figures 9 and 10 show the results of a similar analysis for two different measures of inflation: the NAC CPI and GDP deflator. From Figure 1, one can conclude that both measures are close, but diverge during extended periods and have peaks at different years. Therefore, the CPI (7) and DGDP NAC (8) are slightly different:

$$\pi(t) = 1.755(t-2) + 0.0361; \qquad 1965 \le t \le 1986$$
(0.30) (0.004)
$$\pi(t) = 0.958l(t-2) + 0.0130; \qquad t \ge 1987 \qquad (10)$$
(0.17) (0.002)
$$\pi(t) = 1.734l(t-1) + 0.0373; \qquad 1965 \le t \le 1986$$
(0.23) (0.003)
$$\pi(t) = 1.439l(t-1) + 0.00479; \qquad t \ge 1987 \qquad (11)$$
(0.17) (0.002)

The most important difference is the nonzero lags, t_1, in (10) and (11) before and after the structural break. The rate of CPI inflation lags behind the change in labor force by two years and the DGDP NAC – by one. This allows inflation forecasting at a two- and one-year horizons, respectively. To a large extent, these lags are defined by the peak inflation in the 1970s. Since the late 1990s, inflation is constant and hardly adds something to the resolution of time lags.

All coefficients are obtained using the BEM with the *LSQ* fitting between the cumulative curves. The slope ratio is 1.83 and 1.21 for the CPI and DGDP, respectively. Before 1986, both intercepts are close. After 1986, the DGDP intercept is close to zero and does not prevent deflation when the level of labor force falls. For the CPI, the long-term rate of inflation is 1.3% per year, which is slightly lower the target value of 2%.

The observed and predicted time series of the CPI and DGDP were successfully tested for co-integration. The Johansen test showed the maximum rank 1 for both cases. For the relevant residuals, the ADF and Phillips-Perron tests rejected the null of a unit root. Hence, the observed and predicted cumulative curves are co-integrated, with the predictor (the change in labor force) leading by one (DGDP) and two (CPI) years. The coefficient of determination for the cumulative curves in both cases is larger than 99.8%.

The CPI time series is characterized by the average value of 0.035 and standard deviation =0.021 for the period between 1965 and 2012. These values are close to those obtained for the NAC DGDP series: 0.034 and 0.022, respectively. Between 1965 and 2012, the naïve prediction for the CPI has RMSFE=0.014 at a one-year horizon and RMSFE=0.018 at a two-year horizon. For the DGDP, at a one-year horizon RMSFE=0.011. These values define the reference forecasting precision.

For the observed and predicted CPI NAC times series, the coefficient of determination, R^2=0.68, is lower and RMSFE=0.0118 (at a two year horizon) is higher than those for the DGDP NAC: R^2=0.82 and RMSFE=0.0095 (at a one year horizon), respectively. Even small differences between the DGDP and CPI (cross correlation coefficient is 0.92) result in a large difference in statistical estimates. However, both models are superior to the naive forecasting. The CPI forecast at a two-year horizon is by 70 per cent (0.011/0.018) more precise. The DGDP forecasting precision is by 20% better than the naive one. This result is obtained with the AMS labor force time series, which is likely noisy due to data scaling from the survey to the total population. The precision of labor force estimates can be further improved. It is worth noting that the estimates of RMS(F)E obtained for the cumulative time series are as follows: 0.027 for the DGDP Euro; 0.019 for the DGDP NAC; 0.031 for the CPI NAC.

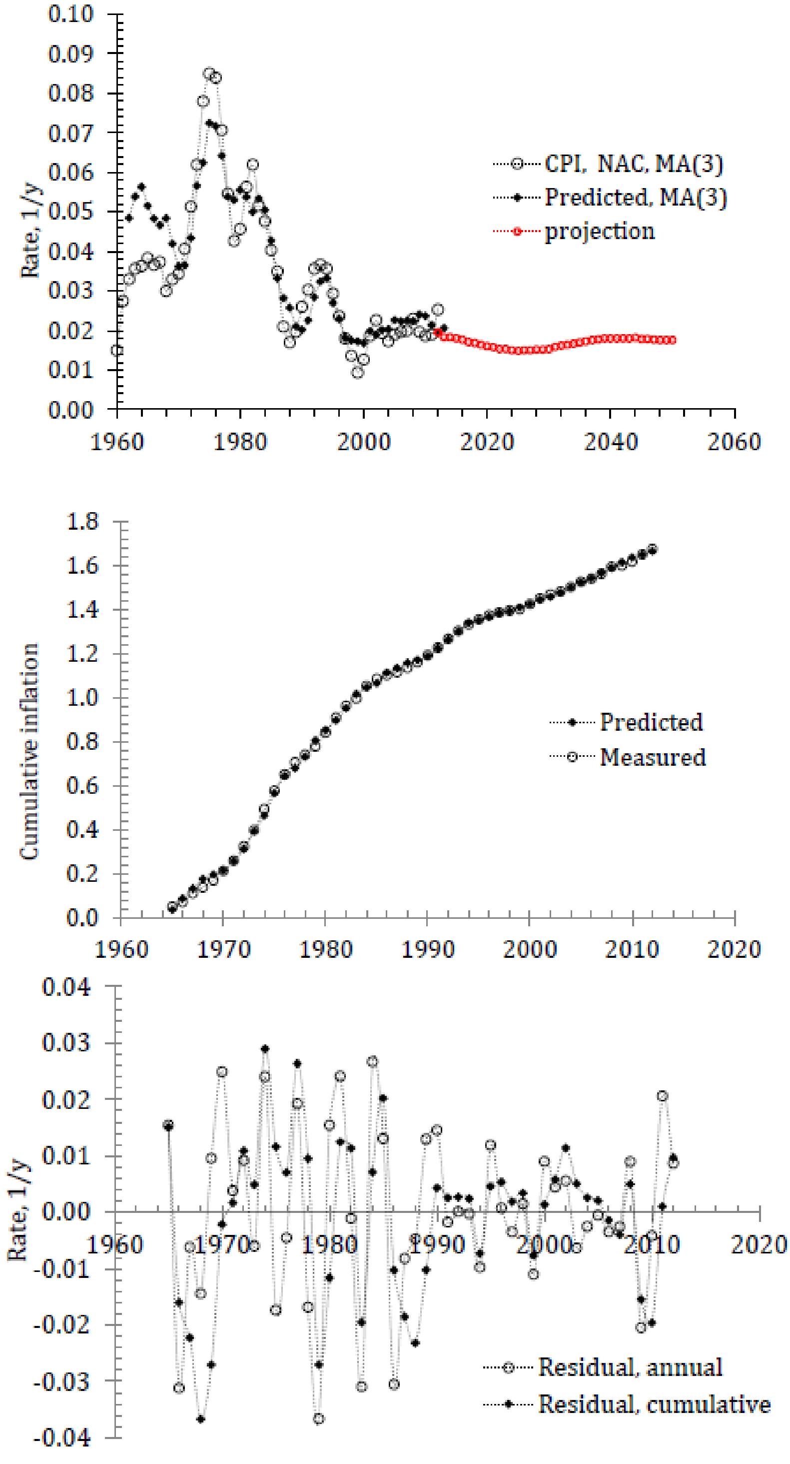

Figure 9. Comparison of the observed (CPI NAC) and predicted inflation in Austria.
Upper panel: The annual readings of observed and predicted inflation smoothed with MA(3). The rate of inflation is projected through 2050. Middle panel: The cumulative curved of observed and predicted inflation since 1965. Lower panel: The annual and cumulative model errors

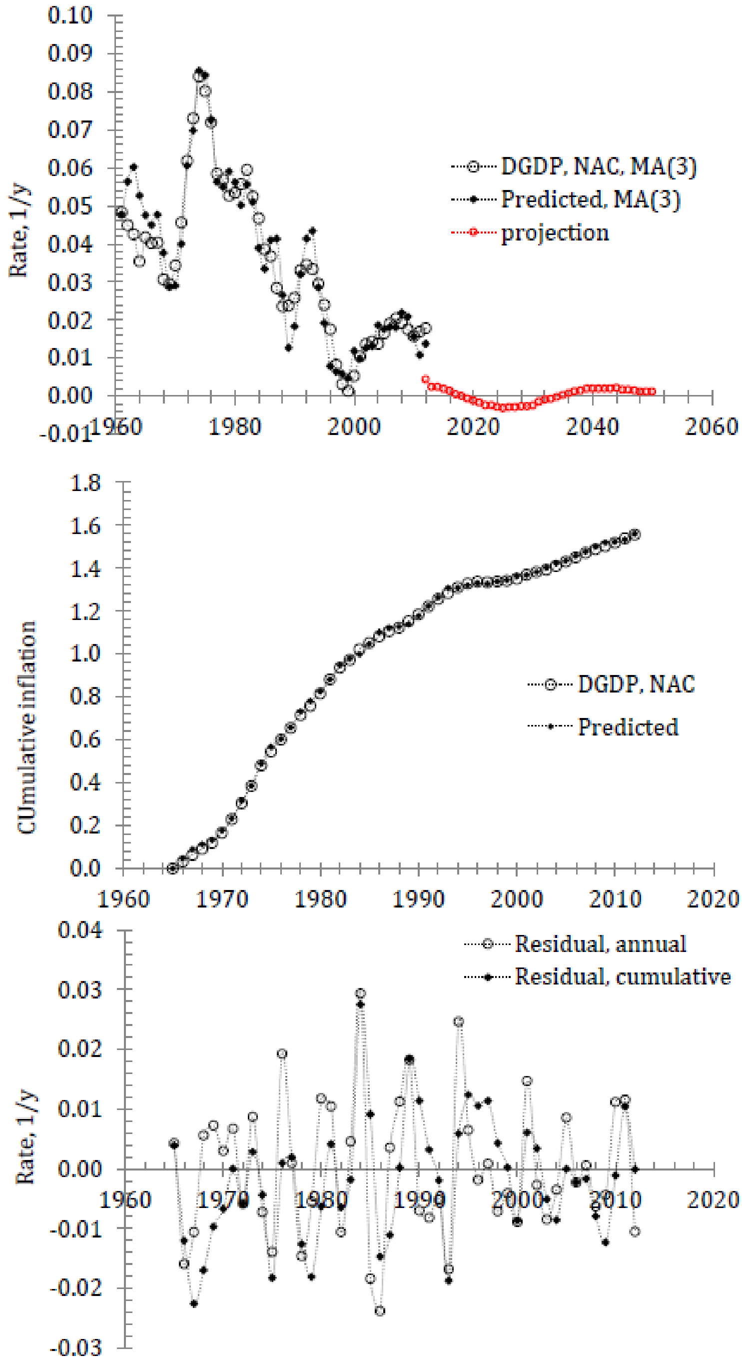

Figure 10. Same as in Figure 9 for the DGDP NAC

The DGDP NAC, being the most complete measure of price inflation reflecting the behavior of the Austrian economy as a whole, demonstrates the lowermost scattering in the model residual: RMSFE=0.0095 for the period between 1965 and 2012. Normalizing to the standard deviations in the original DGDP series one obtains 0.0095/0.022=0.43 for the NAC DGDP and 0.026/0.044=0.59 for the DGDP Euro. For the CPI, this ratio is 0.011/0.021=0.52. The relative improvement in the variability of residual errors does not differ much.

The labor force projection implies a very low but positive rate of growth in consumer prices through 2050. The DGDP NAC will experience approximately 15 year deflationary period in line with the prediction for the GDDP Euro. The consumer price inflation will hover around 1.3% per year between 2010 and 2050, as the intercept in (11) for the period after 1986 and the labor force projection imply. This prediction undermines the capability of the OeNB to retain inflation at the target level. In reality, the period of 2% inflation in Austria observed in the 2000s is the result of quasi-constant growth in labor force (see Figure 3). With the decaying labor force, the Austrian National Bank will not be able to return inflation to its target value.

It has been confirmed above that both inflation and unemployment in Austria are linear functions of labor force. For inflation, time lags depend on the selected measure. All relationships are characterized by a structural break. There is no need to apply generalized relationship (4). However, relationships (8) through (11) demonstrate an excellent predictive power separately and their sum should also work well. There is another important feature of the original time series associated with the use of (4). Measurement errors make the prediction of annual time series less reliable during the periods of weak changes (*e.g.*, the 2000s), when the annual change in labor force is lower than the uncertainty of the labor force estimates. Then, the observed change is statistically insignificant, as we have obtained for the rate of unemployment in Austria. Relationship (4) provides a potential way to improve the overall match. Since all the involved variables have almost independent measurement errors one can expect additional destructive interference of these errors when they are used altogether.

For the generalized representation, we model the DGDP NAC. We have estimated coefficients in relationship (4), with a possible break between 1980 and 1990, using the BEM and the *LSQ* fitting applied to the OECD unemployment rate and the AMS labor force as predictors:

$$\pi(t) = 1.0l(t) - u(t) + 0.068;\ t \leq 1986$$

$$\pi(t) = 0.8l(t) - u(t) + 0.077;\ t \geq 1987 \qquad (12)$$

Figure 11 displays the DGDP NAC and inflation predicted by (12). We expect that (12) is less sensitive to the changes in unemployment and labor force definitions. Unemployment is a smaller share of labor force and any change in the rate of unemployment is automatically included into the labor force change. Nevertheless, the changes in unemployment and employment definitions are not necessarily synchronized. Despite these definitional problems, the agreement between the predicted and observed curves is remarkable. For the annual readings between 1962 and 2012, R^2=0.76 and RMSE=0.010. This is a better result than that obtained from the naive prediction (RMSFE=0.011) for the same period, but it is inferior to the RMSFE provided by (11). The cumulative curves are cointegrated and R^2=0.999. All in all, the labor force and unemployment describe the integral evolution of inflation since 1962 with an increasing relative accuracy.

Conclusion

On average, the rate of CPI inflation in the 21st century was 2.1% per year and only 1.7% per year for the GDP deflator. The CPI inflation is close to that explicitly defined by the monetary policy adopted by the European System of Central Banks and by the National Bank of Austria. This observation is considered as the result of OeNB's monetary policy. At the same time, the rate of the overall price inflation has been following the revealed dependence on the change in labor force. Hence, the monetary policy oriented to price stability is currently synchronized with the natural economic evolution. This monetary policy has not been disturbing (i.e. showing any effect on) relationship (11) describing the last 50 years of inflation. Therefore, the future evolution of price inflation will be likely controlled by the change in labor force not by the OeNB. The projection of workforce published by Statistik Austria implies that in the long run the rate of CPI inflation will be 1.3% per year and the GDP deflator will sink below zero between 2018 and 2034.

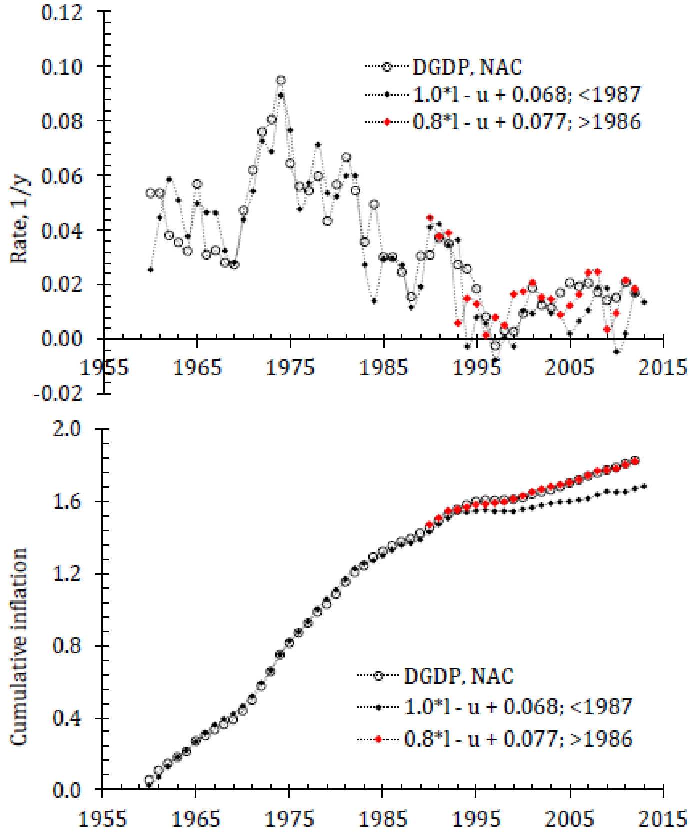

Figure 11. Comparison of the observed (DGDP Euro and predicted inflation in Austria.
The upper panel displays annual readings and the lower one – cumulative inflation since 1962. The predicted inflation is a linear function of the labor force change and unemployment as defined by (12)

Austria provides a good opportunity not only to model the dependence between inflation, unemployment, and labor force change, but also to evaluate the consistency of various definitions of the studied variables. Despite the well-documented changes in units of measurements, these variables do not lose their intrinsic links. There is no reason to think that the inherent relationships will disappear in the future.

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OVERSUPPLY OF LABOR AND OTHER PECULIARITIES OF ARTS LABOR MARKET

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Abstract:

There are several striking peculiarities of the arts labor market that have attracted the attentions of researchers in the last several decades: first is constant long run excess supply of arts labor; second, artists are more likely to be multiple-job-holders than other professions; third, artists pay significant earning penalties; finally, there are huge variations in artists earnings and huge inequalities among artists themselves. In order to explain these peculiarities, in this paper we developed two dynamic models of an artist's behavior and arts labor supply.

In the first model proposed here an artist is depicted as someone who is hired on the arts labor market and paid for his artistic time. In the second model an artist is described as someone who sells his products, like paintings for instance, on the market for artistic products. In order to make these models dynamic, an artist's productivity is here supposed to be a function of accumulated human capital of the artist. As a consequence, the supply of labor in the arts market appears as the result of an inter-temporal process of resources allocation. Both models end with the same result: the cost of producing a unit of an artistic commodity in a particular year should be equal to the present value of expected streams of all monetary and nonmonetary benefits generated by production of a given artistic unit. This result appears to be pretty suitable for formalization of several existing hypotheses aimed at explaining arts labor market peculiarities. Especially, by referring to the stream of expected nonmonetary benefits, models developed here are able to formalize the most promising among these hypotheses according to which an artist's need for self-discovery and self-actualization is the driving force in explaining the oversupply of arts labor.

Keywords: household production function, allocation of time, arts, expected benefits.

JEL Classification: Z10, Z11, J22, J24, J31.

1. Introduction

There are several striking peculiarities of the arts labor market that have attracted the attentions of researchers in the last several decades[29]. First and most important is constant oversupply of arts labor and related constant unemployment on the arts labor market. These phenomena can be documented with the plenty of data and anecdotal evidences since the end of nineteen century till our

[29] For more detailed survey and analysis of arts market peculiarities see Alper and Wassall (2006), Towse (2006), Menger (2006) and Menger (2002).

times. Persistent unemployment is not characteristic of other professions which might be characterized only with cyclical and temporary unemployment. Secondly, as a consequence, artists are more likely to be multiple-job-holders than any other professions. Very often, especially in the early years of their career, artists cannot cover even their basic needs by the earning from artistic work. Instead, they make living by doing non-artistic jobs. Thirdly, artists pay significant earning penalties. In other words, they have a lower level of average earnings than occupations with similar level of education. Interestingly enough, their earning from artistic job is not related to their formal artistic education. Even more interesting, their earning from non-artistic job is significantly related to their artistic education. Finally, there are huge variations in artists' earnings and huge inequalities among artists themselves. Art is, obviously, risky business.

The explanations offered so far are based on David C. Throsby's model (Throsby (1994b)) of an artist's behavior. It explains this phenomenon by the operation of the income effect in the choice between earned income and arts time. Arts time, as we know, provides satisfactions to artists. Throsby's model is essentially static. It does not consider inter-temporal aspects of the supply of labor. These aspects are especially important if one considers the supply of arts labor. Artists' wages and prices of their works (paintings, for example) are a function of accumulated human capital of artists. This accumulation of human capital, on the other hand, can result both from investment in formal education and from previous artistic practice and experience of artists. Previous practice and experience is, in the case of arts, according to empirical works and casual observation, much more important than investment in formal education.

Once the analysis is expanded to capture an artist's human capital accumulation, the supply of labor in the arts market appears as the result of an inter-temporal process of resources allocation that is based on accumulation of a human capital decision. This dynamic extension of the basic model allows some other, even more important, peculiarities of the arts labor market to be explained (oversupply of arts labor, earning penalties, poverty among artists, and similar). In this article two such dynamic models of an artist's behavior have been developed. Both are based on a household production function approach. Both models are also based on the assumption that artists are multiple-job-holders and that they have to decide how much of their time to devote to artistic work and how much time to non-artistic work. It is in accordance with a casual observation that artists, especially in the early ages of their career, do both non-artistic jobs as well as artistic ones. The first model that is proposed here is based on the assumption that artists are hired on the arts labor market and paid for their artistic time. This approach was once proposed by Caserta and Cuccia (2001) but has not been solved and developed further. The second model is based on the assumption that artists sell their products, like paintings for instance, on the market. Labor supply is in this case derived from the artist's product supply function.

In the second section of the article a short survey of the static model developed by Throsby (1994b) is given first. For the sake of simplicity and comparability the model is a bit modified. The following two sections are the core of the article: in the third section the first dynamic model is given, while in the fourth section of the article the second model is presented. Implications of the models are discussed in the fifth section.

2. A Static approach to arts labor supply

In Throsby's work preference model (Throsby (1994b)) it is assumed that an artist maximizes the following utility function

$$U = U(L^M, X) \tag{1}$$

With L^M we present time devoted to an artistic activity, which by definition provides pleasure to the artist[30] . On the other hand, X presents quantity of all other market goods. Needless to say, both partial derivatives of this utility function are positive.

Artists are, of course, paid for their time devoted to art. If their hourly wage from this activity is w^M than their income earned from arts is equal to $L^M w^M$. Artists, however, have an option to devote part of their time to non-artistic activities (L^n) . If their wage rate earned at a non-artistic job is w^n , than their income earned from non-artistic activities will be $L^n w^n$. An artist total income earned from both activities will be $L^n w^n + L^M w^M$. So, their income constraint becomes

$$pX = L^n w^n + L^M w^M$$

where: p presents the price of market goods. The crucial assumption of Throsby's work preference model is that non-arts wages are higher than arts wages, $w^n > w^M$.

Artists are also constrained by disposable time: the time they devote to artistic (L^M) and non-artistic (L^n) activities should be equal to their disposable time (L). Formally [31]

$$L^M + L^n = L$$

The time constraint and income constraint can be combined to give one constraint of the following form[32]

$$L^M w^n + pX = Lw^n + L^M w^M \qquad (2)$$

Behavior of an artist can now be outlined with expression (1) and (2). The artist chooses the value of L^M and X in order to maximize (1) subject to the constraint given by (2). In order to solve the problem we form Lagrange of the following form

$$\mathrm{L} = U(L^M, X) - \lambda[L^M w^n + pX - Lw^n + L^M w^M] \qquad (3)$$

The first order condition requires a partial derivative of with respect to L^M and X to be equal to zero. The second order condition will be, for the sake of simplicity, skipped. Solutions we get are[33]

$$\frac{\partial U}{\partial L^M} = \lambda(w^n - w^M)$$
$$\frac{\partial U}{\partial X} = \lambda p$$

---

[30] Although in his formal analysis Throsby uses general utility function, in the graphical presentation he, in fact, applies quite specific kind of quasi linear utility function. By doing so he was able to present a typical artist as someone who has an absolute preference to artistic work once his basic needs are satisfied.

[31] In this presentation Throsbys' initial model is somewhat modified. We use the amount of disposable time devoted to artistic and non-artistic work while Throsby uses their share in disposable time.

[32] From the expression for time constraint it follows that $L^n = L - L^M$. By substituting this for L^n in income constraint and rearranging we get the constraint given by expression (2).

[33] Solution follows from the following two first order conditions:

$$\frac{\partial \mathrm{L}}{\partial L^M} = \frac{\partial U}{\partial L^M} + \lambda(w^n - w^M) = 0$$
$$\frac{\partial \mathrm{L}}{\partial X} = \frac{\partial U}{\partial X} - \lambda p = 0$$

Consequently, the optimal solution requires the marginal rate of substitution of artistic time for market goods (MRS) to be equal to

$$MRS = -\frac{\Delta X}{\Delta L^M} = \frac{\dfrac{\partial U}{\partial L^M}}{\dfrac{\partial U}{\partial X}} = \frac{w^n - w^M}{p} \tag{4}$$

Obviously, any time wage differential $w^n - w^M$ changes, either because of the change of w^n or because of the change of w^M, it will generate a substitution as well as an income effect. The substitution effect implies that when the wage differential is reduced more time will be devoted to a preferred artistic activity. It happens because, as expression (4) shows, shifting labor from non-pleasurable to pleasurable artistic activity is now less costly. It may happen for example as a result of the increase of wage rate of an artistic activity w^M. It is, indeed, something that happens during the artist's career as a result of his professional development. If, on the other hand, the wage differential increases, as a result of the increase of w^n for example, labor will be shifted from pleasurable to non-pleasurable activities: it is now more costly to shift labor from a non-pleasurable to pleasurable activity. This effect may be weakened or even reversed by the income effect. It may easily happen that the increase in wage differential caused by the increase of w^n results in shifting labor from non-pleasurable to pleasurable activities. In such a case higher income, resulting from the increase of wage rate of non-pleasurable activities, is used to "buy" time for pleasurable artistic activities. This is exactly something that characterizes the artist's behavior according to Throsby.

Apart from the substitution and income effect there is the price effect as well. Any increase of a market goods price will reduce the right hand side of expression (4). Conversely, any decrease of the price of market goods will increase it. This will produce a substitution as well as the income effect. If the price level increases, assuming overall income does not change, more time will be devoted to pleasurable activities: the cost of substituting non-pleasurable for pleasurable activities is now smaller. Conversely, if the price level decreases, assuming constant income, this cost will be higher and, as a consequence, more time will be devoted to non-pleasurable than to pleasurable activities. Note, however, that if the price level decreases and, as a consequence, income increases, this will put in force the income effect that may result in the increase of pleasurable relative to non-pleasurable activities.

The above is even more obvious if we watch the behavior of different labor shares in disposable time. Once we have the solution of the model (X^n) it is easy to calculate a share of artistic time in overall disposable time. Substituting solutions in equation (2), dividing it with L and transforming we get

$$l^M = \frac{w^n - px^*}{w^n - w^M} \tag{5}$$

where $l^M = \dfrac{L^M}{L}$, while $x^* = \dfrac{X^*}{L}$. This equation has the following partials, which describe the responsiveness of artistic labor supply to changes in commodity price, arts wage, and non-arts wage:

$$\frac{\partial l^M}{\partial p} = \frac{-x^*}{w^n - w^M} < 0$$
$$\frac{\partial l^M}{\partial w^M} = \frac{w^n - px^*}{(w^n - w^M)^2} > 0 \tag{6}$$

$$\frac{\partial l^M}{\partial w^n} = \frac{px^* - w^M}{(w^n - w^M)^2} < 0$$

Again, as we see, the model depicts artists as addicted to artistic work. Responsiveness to change in price in equilibrium is consistent with artists' peculiar behavior. Firstly, the more severe the budget constraints are, the less time artists will devote to artistic activities (the first partial). Secondly, the higher the arts wage is, the more time an artist will devote to artistic activities (the second partial). Finally and most interestingly, the higher the non-arts wage is, the more hours an artists will devote to their artistic activities (the third partial). As Merijn and Madden (2000) noticed, the model is less spectacular for those artists whose arts wages are higher than the non-arts wage, $w^M > w^n$, and who, therefore, performs an artistic activity only. In that case all inequalities in expression (6) turn to zero.

Let us now see what happens if we assume that artists sell their artistic products instead of their artistic time. Assume that quantity of artistic products is, in that case, determined by the artist's production function of the following form

$$M = M(L^M, X^M)$$

where X^M stands for quantity of market goods purchased for the production of artistic products (raw material). If prices of artistic products are given by p^A and prices of raw material s are given by p^M, then the constraint given in expression (2) becomes

$$L^M w^n + pX + p^M X^M = Lw^n + M(L^M, X^M)p^A \tag{7}$$

Accordingly, new Lagrange gets the following form

$$\mathrm{L} = U(L^M, X) - \lambda[L^M w^n + pX + p^M X^M - Lw^n - M(L^M, X^M)p^A] \tag{8}$$

The solution of this problem is

$$\frac{\partial U}{\partial L^M} = \lambda\left(w^n - \frac{\partial M}{\partial L^M} p^A\right)$$

$$\frac{\partial U}{\partial X} = \lambda p$$

$$\frac{\partial M}{\partial X^M} p^A = p^M$$

Since $\frac{\partial M}{\partial L^M}$ presents a marginal product of labor engaged at artistic activities it follows that $\frac{\partial M}{\partial L^M} p^A$ presents the value of a marginal product of labor engaged at artistic activities. In the competitive market this should be equal to an arts gross wage, w^M. Obviously, this approach gives the same solution as the previous one.

Recently Casacuberta and Gandelman (2012) developed more general and more sophisticated model of arts labor supply than one developed by Thorsby and presented above. Firstly, their treatment of leisure is more general. Secondly, they do not assume that artists have absolute preferences toward artistic practicing. Finally, they introduce nonnegative constraints on artistic and non-artistic time and, in that way, explicitly allow for possibility of corner solution. The most general results of this model are, however, close to those proposed by Throsby.

Both above mentioned models are, however, static in its nature. This means that, as Caserta and Cuccia (2001) noticed, an "artist has no past and no future and that wage differential is entirely exogenous". In what follows two dynamic models of an artist's behavior will be developed. The past and future of the artist will be incorporated in it, while wage rates and prices of his products will be endogenously determined.

3. A dynamic model with arts labor hired

In order to develop a sophisticated dynamic model of artist behavior we will rely on household production function approach and the theory of allocation of time developed by Gary Becker and his followers. Especially important here are papers and works written by Becker (1965), Becker (1991), Becker (1993), Grossman (1971), Ghez and Becker (1975), Michael and Becker (1973), Stigler and Becker (1977), Becker *et al.* (1991). According to this approach consumers run the production process using market goods, their own time and other inputs in order to produce commodities for the final consumption. "These commodities include children, prestige and esteem, health, altruism, envy, and pleasure of the senses, and are much smaller in number than the goods consumed" as Becker noticed once (Becker (1991), p. 24). A meal, for example, according to this approach should be understood as a commodity produced using goods purchased, our own time used for purchase of goods and cooking, and the ability to cook as a kind of human capital. Similarly, appreciation of music, as a kind of commodity of "the pleasure of senses", is made by combining market goods or services (CDs, instruments, concerts, music lessons), our own time devoted to it, and the ability to appreciate music, which again depends on specific human capital of individuals. Consequently, our decisions about consumption of certain commodities are governed not solely by market prices of goods and services used in producing certain commodities but by shadow prices of commodities, which also includes the opportunistic price of our time, the price of human capital, and prices of all other household resources involved in production of a given commodity. Therefore, changes in the pattern of demand of market goods and services may not necessarily be the result of changes in market prices and in our tastes but rather the result of changes in the household production technology and / or in the inputs available for production.

More precisely, consumers are, according to this approach, supposed to maximize their utility function subject to the money income constraint, time constraint and to a household production function constraint (Becker (1965), Michael and Becker (1973)). Note that traditional theory of consumer behavior takes into account only the money income constraint. As a consequence the traditional approach gives as a result only the allocation of household money income among different goods and services. The solution of the new approach, on the other hand, apart from the allocation of earnings among different goods, provides the allocation of time among work and consumption as well as allocation of time among different kinds of consumption. Consequently, changes in shadow prices of commodities, which are governed by changes in market goods prices and wage rates, will give rise to different allocation of time and different allocation of money income of households. Note, however, that changes in allocations of earnings and time may result not only from changes in market prices and wages but also from the previous consumption history of individuals. Consumption of certain commodities and experience gained in that way may, in fact, result in the increase of human capital that is relevant for future production of a given commodity. In this case, the cost of production and the shadow price of this commodity will be reduced as a result of this human capital accumulation. Consequently, the consumption of the commodity whose shadow prices falls relatively to others will be increased. This effect is now well known as an addictive effect.

Stigler and Becker (1977), who first discussed addiction effect, choose music appreciation as an example of such an addictive commodity. According to this interpretation, consumption of music is never simple consumption of market goods or services, but rather the consumption of output of productive process that combines market goods and services, consumers' time, human capital and other inputs. Human capital expressed as the ability to enjoy music is of crucial importance. It is an increasing function of weighted cumulative of the previous consumption of music. The more time someone devotes to music consumption, the more knowledgeable and perceptive he becomes, and in that way more productive he will be the next time he consumes music. This effect will reduce the shadow price of music consumption and in that way make music more attractive relative to other commodities. Increased consumption of music will contribute to further increase of human capital, which in turn will further decrease the shadow price and increase consumption of music. And so on. The same applies for all other kinds of art appreciation: having artistic paintings or visiting artistic galleries and museums, watching dramas or operas in theatres, enjoying movies at cinemas or at homes by using CDs, and similar.

Artists, on the other hand, are prone to the same kind of addictive behavior towards art, but they are also paid for the time they devote to the artistic practicing. They "enjoy" the time they devote to practicing art. In other words, they produce and consume the commodity known as art. The quantity of this commodity in a year *j* of an artist's career will be presented by M_j. They also produce and consume all other commodities. In order to make things simple we will assume that quantity of all other commodities in a year *j* can be presented as the commodity Z_j. In that case, the utility function which is being maximized by the artist's household is given by

$$Uf = \sum_{j=1}^{n} \left(\frac{1}{1+\rho}\right)^{j} U\left[M_j, Z_j\right] \tag{9}$$

where ρ stands for the time preference rate, while n presents the remaining years of a career of the particular artist.

In order to produce a commodity of art artists use market goods, their time, and human capital relevant for production of this commodity. This can formally be presented using the following artists' household production function

$$M_j = M\left[X_j^M, L_j^M, H_j\right] \tag{10}$$

where X_j^M presents quantity of market goods used in producing arts in a year j, L_j^M stands for time devoted to arts production in a year j, while H_j stands for human capital used for that purpose in a year j. M_j is an output of this production function, but it is also an argument in the utility function. This output will be from now on called simply art and will be expressed in some kind of an efficiency unit. Each unit of time devoted to art will produce the same amount of art efficiency units as long as the amount of human capital stays the same. When the amount of human capital changes, the number of art efficiency units per unit of time changes. Note that this household production function differs from the one used by Stigler and Becker (1977) to describe behavior of a consumer of arts because it explicitly uses market goods as an argument of the function. It also differs, in the same way, from the production function proposed by Caserta and Cuccia (2001) for the description of an artist's behavior. Although artistic market goods may be skipped when dealing with production function of arts consumers, it is pretty unrealistic to miss such an important input when dealing with production function of an artist.

Production of all other commodities can be presented with the household production function of the following form

$$Z_j = Z\left[X_j^Z, L_j^Z\right] \tag{11}$$

Z_j stands for the quantity of all other commodities in a year j, X_j^Z presents quantity of market goods purchased for the production of all other commodities in a year j (purchase of food, shoes, clothing, and similar), while L_j^Z measures time used in production of these commodities in a year j (time to buy goods, time to make meals, to put make up, and similar).

Human capital, which is an argument in the production function of an artistic commodity, is itself the function of previous artistic experience and production of art. This is how addictive effect enters in our analysis. It can formally be presented by the following human capital production function

$$H_j = h\left[M_{j-1}, M_{j-2}, M_{j-3}, ..., E_j\right] \tag{12}$$

So, we assume that the entire work history of an artist can have influence on his human capital relevant for production of an artistic commodity. In order to allow for influence of formal education on artists' human capital we also introduce E_j as a measure of artists' years of education[34].

Important difference between artists and consumers of art is that artists are paid for their artistic experience. More experienced they are and more human capital they have, they will be able to produce more art efficiency units. So, hourly wages of artists will be the increasing function of their human capital. Formally

$$w_j^M = w^M\left(H_j\right) \tag{13}$$

In other words, an hourly wage of an artist in a year j is the increasing function of artists' human capital attained in that year, H_j. Obviously, their total earnings from artistic work in a year j are equal to $w_j^M L_j^M$. It is important to have in mind that by w_j^M we do not understand the wage per hour of time in which an artist is hired, but the wage per hour of the entire time devoted to arts practicing. As a result, changes of w_j^M are the result of simultaneous changes of a wage per hour of time in which an artist is hired for his artistic works and consequent changes of a share of time the artist is being hired in total time devoted to art practicing L_j^M.

Note, however, that artists unlike most of other professions and workers very often make their living by working other non-artistic jobs as well [35]. Income earned by artistic practice is most of the time, especially in the early ages of their career, not enough to support their living and their artistic persuasion. So, they devote L_j^n units of disposable time in a year j doing non-artistic jobs. Assuming for the sake of simplicity that the wage of non-artistic work is constant and equal to w^n, we conclude

[34] Existing researches, although scarce, seem to suggest three interesting conclusions regarding the importance of human capital for artists' productivity and for their earnings. Firstly, years of schooling, as a measure of formal education, have no influence on artists' earnings from artistic works. In some researches even negative coefficients have been obtained. Secondly, formal education has significant influence on artists' earnings from non-artistic works. Finally, artistic earnings are found to be influenced by years of artists' experience, which measure on-the-job-training or learning by doing as it is sometimes called. While the first two results are surprising, the last one is quite in line with findings for other professions. It is probably the reason why this result has not been stressed enough in previous researches. Nevertheless, it is very important and it motivates the approach taken in this paper. For more detailed survey and discussion of the above issues see Alper and Wassall (2006), Towse (2006), Throsby (1994b), Throsby (1994a), Throsby (2007) and Caserta and Cuccia (2001).

[35] Multiple job-holding is widespread among artists. It has been documented and analyzed by a great number of cultural economists. See for example: Throsby (1992), Throsby (1994b), Throsby (1994a), Throsby (2007), Jeffri Joan and Mary (1991), Merijn and Madden (2000), Alper and Wassall (2006) and Abbing (2004). A more subtle analysis would require, as Merijn and Madden (2000) and Throsby (2007) insisted, artistic working time to be divided into non-art, art related (like teacher of art, for example), and pure art working time. Within pure artistic working time it is also possible to make further distinction between those activities that are more artistically rewarding but less financially attractive and those activities that are less artistically rewarding but more financially attractive (Throsby (2007), Bryant and Throsby (2006)). No doubt, even pure artistic jobs differ among themselves by the quantity of artistically rewarding activities in their content. All this can make empirical analysis of this market much more complicated than in other cases.

that their non-artistic income in a year j should be equal to $w^n L_j^n$. Their total earnings from artistic and non-artistic work are therefore equal to $w^n L_j^n + w_j^M L_j^M$. The above consideration is, of course, based on the assumption that hourly wages of non-artistic jobs are higher than those of artistic jobs. The reason why in this situation artists devote part of their disposable time to art lies, of course, in the fact that, apart from gaining certain money income from artistic production, artists receive significant stream of nonmonetary benefits that artistic practice brings by itself. If and when, in later years of their career, artists' wages approach the level of non-artistic wages or above it artists devote their entire working time to artistic jobs. More generally, the higher the level of w_j^M, the higher proportion of L_j^M in disposable time will be. The artist's career is characterized by a pretty stable increase in human capital and, therefore, by ever increasing value of w_j^M, which naturally leads to the increase of L_j^M.

Relying on previous considerations, we can now introduce two additional constraints encountered by artists. The first one is the income constraint and it says that total artist's income from work and from his wealth in a year should be equal to his market goods expenditure in the given year. More precisely and formally

$$\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^j \left[p^Z X_j^Z + p^M X_j^M\right] = \sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^j \left[w^n L_j^n + w_j^M L_j^M + b_j\right] \quad (14)$$

where r stands for the interest rate, p^Z presents prices of market goods used for production of all other commodities, p^M presents prices of market goods used for production of an artistic commodity, while b_j stands for income earned from the artist's wealth and other sources (social assistance or artist's support programs, for example). Note also that, for the sake of simplicity, we assumed that prices of all market goods are constant in all considered years. Other important constraint that should be taken into account is the time constraint and it says that the time used for artistic and non-artistic work and the time used for production of all other commodities should be equal to the artist's disposable time in every year. Formally

$$L_j^n + L_j^M + L_j^Z + = L_j \quad (15)$$

where L_j presents the artist's disposable time in a year j. From (15) it follows that $L_j^n = L_j - L_j^Z - L_j^M$. By substituting this for L_j^n in income constraint (14) and by rearranging we get expression

$$\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^j \left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M\right] = \sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^j \left[w_j^M L_j^M + w^n L_j + b_j\right] \quad (16)$$

What we got here is, using Becker's terminology, "full income constraint" of an artist. The artist's decision making process is now simplified and presented by the utility function (9) which should be maximized under constraints given by the production functions (10) and (11) and the full income constraint (16). Of course, before that, human capital production function (12) should be substituted for H_j in expression (10), while expression (13) should be substituted for w_j^M in expression (16).[36] The

[36] To get even more realistic model of artist behavior, we could have introduced conditions of non-negativity of artistic and non-artistic time, which would, relying on Kuhn-Tucker, allow us to determine the switching point (corner solution): level of artistic job wage at which artist switch and devote all his disposable time to artistic job (or to non-artistic job). The only reason for not introducing these constraints is to avoid getting complicated and cumbersome results. On the other hand, in

problem can be further simplified by substituting values of X_j^Z, X_j^M, L_j^Z and L_j^M in expression (16) by values of these variables derived from household production functions (10) and (11). In that case the decision making process that outlines the artist's behavior can be described by expression (9) which should be maximized subject to a new modified constraint (16). In order to solve the problem we form the following Lagrange

$$\mathrm{L} = \sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^{j} U\left[M_j, Z_j\right]$$
$$-\lambda\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M - w_j^M L_j^M - w^n L_j - b_j\right] \quad (17)$$

By the first order condition for Z_j, we get the following solution for a commodity Z_j (cf. Appendix 6.1)

$$\frac{\partial U}{\partial Z_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^{j}\left[p^Z \frac{dX_j^Z}{dZ_j} + w^n \frac{dL_j^Z}{dZ_j}\right] = \lambda\left(\frac{1+\rho}{1+r}\right)^{j}\pi_{Z_j} \quad (18)$$

where $\pi_{Z_j} = p^Z \frac{dX_j^Z}{dZ_j} + w^n \frac{dL_j^Z}{dZ_j}$ presents the shadow price of a commodity Z_j. This is a very known solution for allocation of time and income derived by Becker in his already quoted works. It simply says that the marginal utility of a commodity Z_j should be equal to marginal cost of all inputs involved in production of that commodity. Needless to say λ presents, as usual, the marginal utility of money income.

By the first order condition for M_j, we get the following solution for a commodity M_j (cf. Appendix 6.1)

$$\frac{\partial U}{\partial M_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^{j}\left[\frac{p^M}{\frac{\partial M_j}{\partial X_j^M}} + \frac{w^n - w_j^M}{\frac{\partial M_j}{\partial L_j^M}}\right] - \lambda\sum_{v=j}^{n}\frac{(1+\rho)^j}{(1+r)^v} L_v^M \frac{dw_v^M}{dM_j}$$
$$-\sum_{v=j+1}^{n}\frac{(1+\rho)^j}{(1+r)^v}\frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j} \quad (19)$$

By rearranging it we get an equally useful expression

$$\left[p^M \frac{\partial X_j^M}{\partial M_j} + w^n \frac{\partial L_j^M}{\partial M_j}\right] = \frac{1}{\lambda}\left(\frac{1+r}{1+\rho}\right)^{j}\frac{\partial U}{\partial M_j} + \frac{1}{\lambda}\sum_{v=j+1}^{n}\frac{(1+r)^j}{(1+\rho)^v}\frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$
$$+w_j^M \frac{\partial L_j^M}{\partial M_j} + \sum_{v=j}^{n}\frac{(1+r)^j}{(1+r)^v} L_v^M \frac{dw_v^M}{dM_j} \quad (20)$$

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this particular case, switching point can be easily identified by simple intuition: when the sum artist's expected wages from artistic job and expected nonmonetary benefits from artistic job become equal to expected wages from non-artistic job, artist allocates his entire working time solely to artistic job.

Expression (20) provides some important results. The left hand side of this expression presents the value of all costs committed by an artist in a year j for the production of a unit of arts commodity. As we see, this is very similar to the shadow price π_{Z_j} obtained previously for the commodity Z_j in expression (18). So, we can say that it presents the shadow price of a unit of commodity M_j produced in a year j. On the right hand side we have four parts. Together, all of them present a stream of benefits that an artist has from this arts unit production in a year j. The first two elements present monetary equivalent of nonmonetary benefits generated by producing a unit of arts, while the last two elements present monetary benefits generated by this production. The first and third elements present benefits grasped immediately in a year j. The second and forth elements, on the other hand, present streams of benefits that are supposed to be generated from year j to the end of the artist's career, given as a present value in a year j. More precisely, the first element on the right hand side presents monetary equivalent of nonmonetary benefits gained in a year j which is the result of "pleasure" that dealing with art itself provides to artists. Since, however, the artist's activity in a year j increases his future human capital in all years that follow up to the end of her career $\left(\partial H_v / \partial M_j\right)$, it will inevitably contribute to the increase of productivity of his artistic production $\left(\partial M_v / \partial H_v\right)$ in all years that follow. This, in turn, will contribute to the increase of his future "pleasure" of dealing with art $\left(\partial U / \partial M_v\right)$ in all years that follow to the end of his career. This future stream of nonmonetary benefits is presented by the second part of the right hand side of expression (20). The third element is easy to understand: it presents the wage earned in a year j from producing a unit of art. However, monetary benefits do not end with this. Since the artist's activity in a year j contributes to the increase of human capital in all years that follows up to the end of the artist's career and since the artist's future wages are influenced by this increase of human capital $\left(\partial w_v^M / \partial M_j\right)$, we can expect the artist's activity in a year j to produce a stream of wage increase in all years that follows up to the end of the artist's career. This stream of future monetary benefits is given by the last part of expression (20). At the end of this section, it is worth noting that results given in expressions (19) and (20) are, in fact, very simple and in accordance to what someone would expect to get by relying on simple intuition.

4. A Dynamic model with arts products sold

In the previous consideration we assumed that artists are paid for the time they devote to art practicing. In many cases this is a pretty realistic picture of what is really happening on the market. Actors, singers, musicians, dancers and other artists engaged in so called *performing arts* are, for example, paid for their time being hired. In that case artistic organizations that hire them have their own production function and their own (profit, artistic quality or other) maximizing goals. Demands for artists' labor and other inputs are in that case derived from this process of maximization under production function and other constraints encountered by these organizations. Other kinds of artists are, however, paid for their products, that is for what we notified previously with M_j. A creative painting is an obvious example[37]. Creative painters are paid for their pictures. The same apply for sculptors, writers, composers, craftspeople and some other kinds of so called *creative artists* [38]. The decision making

[37] In the case of creative painting it is necessary to make distinction between primary and secondary market of creative paintings. Our focus here is on the primary market of paintings and on prices of paintings on that market. For more detailed exposition of the primary and secondary market of creative paintings and of artistic works market in general see Heilbrun and Gray (2004), p. 165-187.

[38] Although somewhat blurred, the distinction between creative and performing artists is a very useful one. Merijn and Madden (2000) pointed out to seven important differences between them. The first one is that creative artists are self-employed, while performing artists work under short time contracts. The second one, and for this analysis the most important one, is related to the previous one: creative artists are paid for their "products", while performing artists are paid

process is in this case somewhat different. Artists are paid for their products. Their household production function directly generates the production function of the entire art industry. The labor supply function is derived from the process of maximization under these constraints. In what follows we will try to describe the artist's behavior in this very common situation.

As in the previous case artists are supposed to maximize the utility function (9). Household production functions are also given by previous expressions (10) and (11). The human capital production function, which is supposed to be substituted in (10), is like before given with expression (12). The time constraint that an artist encounters is also the same, expression (15). Their income constraint is, however, different from that in the previous case. Of course, they are, for the same reason as before, supposed to do artistic as well as non-artistic jobs. Their earnings from non-artistic jobs are the same as in the previous case and they are given by $w_n L_j^n$. However, since they are selling their artistic products, their earnings from artistic work are now given by the following expression:

$$p^A M_j = p^A M\left[X_j^M, L_j^M, H_j\right]$$

A new element here is p^A and it presents the price of an artistic product measured per efficiency unit. We supposed here that this market price is constant. Note, however, that this does not mean that the price of the artist's works (paintings, for example) does not change during the artist's career. On the contrary, prices of the artist's works will increase as a result of accumulation of human capital, which is given as a function of previous artistic experience of the artist. To understand this notice that, as we already said, M_j does not measure quantity of works but quantity of works of the same efficiency units. It measures not just the number of creative products (paintings, for example), but their quality as well. And the quality is what increases as a result of human capital accumulation. We may, for example, measure it in efficiency units of an artist with no experience, that is, with zero years of experience. The number of creative works made by an artist with j years of experience can be in that case presented by $M\left[X_j^M, L_j^M, H_0\right]$. The previous expression for an artist's earnings from artistic work can be transformed in the following way:

$$p^A M_j = p^A\left(\frac{M\left[X_j^M, L_j^M, H_j\right]}{M\left[X_j^M, L_j^M, H_0\right]}\right) M\left[X_j^M, L_j^M, H_0\right] = p_j^a M\left[X_j^M, L_j^M, H_0\right]$$

Note that:

$$p_j^a = p^A\left(\frac{M\left[X_j^M, L_j^M, H_j\right]}{M\left[X_j^M, L_j^M, H_0\right]}\right) \quad (21)$$

presents price of one painting or one artistic work in general of an artist with j years of practice, while:

$$\frac{M\left[X_j^M, L_j^M, H_j\right]}{M\left[X_j^M, L_j^M, H_0\right]}$$

per hour hired. The third one is that creators are restricted by income constraint, while performers mostly have restriction regarding availability of works and contracts. The forth one is that creators work individually, while performers work with others. The fifth one is that the work of creators is valued according to their innovations, while the work of performers is characterized by craftsmanship and technical skill. The sixth one is that creators have high production costs, while performers have low production costs. Finally, creators are not unionized like performers.

stands for the number of efficiency units per one painting / work of an artist with j years of practice. More precisely it presents quality of the painting measured in efficiency units of the artist's first picture in his career. It is obvious, from expression (21), that the prices of the artist's products are not constant and that they have their own time path during the artist's career. They are a function of an artist's human capital and they increase with the artist's years of experience[39].

This picture is somewhat complicated by the fact that, especially now days with the development of new reproducing technologies, in very many cases artists do not sell their products, but rather sell their copy rights to publishing and recording companies. This is a case with writers, composers, some singers, and similar. In return they get a stream of income, known as a royalty (10 to 15% of earnings), rather than a lump sum of money in the form of the price of an artistic product p_j^a. In order to make the analysis simple, we will assume that in these cases artists also receive the price p_j^a for their products. This price will be defined here as equivalent to the net present value of the expected stream of royalties[40]. Bearing this clarification in mind we can now provide the following modified expression for the artist's income constraint:

$$\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^{Z}X_{j}^{Z}+p^{M}X_{j}^{M}\right]=\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[w^{n}L_{j}^{n}+p^{A}M_{j}+b_{j}\right] \tag{22}$$

From the time constraint it follows that $L_j^n = L_j - L_j^Z - L_j^M$. By substituting for L_j^n in income constraint (22) and rearranging, we get the full income constraint:

$$\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^{Z}X_{j}^{Z}+p^{M}X_{j}^{M}+w^{n}L_{j}^{Z}+w^{n}L_{j}^{M}\right]=\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^{A}M_{j}+w^{n}L_{j}+b_{j}\right] \tag{23}$$

Behavior of artists can now be outlined by the utility function (9) which is supposed to be maximized under constraints given by the production functions (10), (11) and the full income constraint (23). The problem can be further simplified by substituting values of X_j^Z, X_j^M, L_j^Z and L_j^M in expression (23) by values of these variables derived from household production functions (10) and (11). The decision making process that describes the artist's behavior can now be described by the utility function (9) which should be maximized subject to a newly modified constraint (23). In order to solve the problem we can form the following Lagrange:

$$\begin{aligned}\mathrm{L} &= \sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^{j}U\left[M_{j},Z_{j}\right]\\ &-\lambda\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^{Z}X_{j}^{Z}+p^{M}X_{j}^{M}+w^{n}L_{j}^{Z}+w^{n}L_{j}^{M}-p^{A}M_{j}-w^{n}L_{j}-b_{j}\right]\end{aligned} \tag{24}$$

The first order condition for the solution of the problem requires that partial derivatives of Lagrange with respect to M_j and Z_j be equal to zero. For the sake of simplicity, we again skip

[39] Note, however, that apart from time path of painters an average price of a picture, every picture produced in the particular year has its' own time path. This time path is determined by the forces that determine movements on the secondary market of pictures (Heilbrun and Gray (2004)).

[40] For interesting discussion on the issue of human capital and copy rights see Towse (2006). Note also that in some countries even painters receive part of their income in the form of a stream of income. This is the case in all countries that have adopted the so called resale right (droit de suite) according to which authors receive percentage of price every time his picture is resold (3% in EU, 5% in California). For more detailed discussion see Heilbrun and Gray (2004), p. 176.

consideration of the second order condition. Using the described procedure we get the solution for commodity Z_j which is exactly the same as the one obtained previously in expression (18). As we know, the marginal utility of commodity Z_j should be equal to the marginal cost of all inputs involved in production of that commodity, which is equal to the shadow price of commodity Z_j.

By the first order condition for M_j, we get the following solution for a commodity M_j (cf. Appendix 6.2)

$$\frac{\partial U}{\partial M_j}=\lambda\left(\frac{1+\rho}{1+r}\right)^j\left[\frac{p^M}{\frac{\partial M_j}{\partial X_j^M}}+\frac{w^n-p^A\frac{\partial M_j}{\partial L_j^M}}{\frac{\partial M_j}{\partial L_j^M}}\right]$$
$$-\lambda p^A\sum_{v=j+1}^{n}\frac{(1+\rho)^j}{(1+r)^v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}-\sum_{v=j+1}^{n}\frac{(1+\rho)^j}{(1+\rho)^v}\frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j} \quad (25)$$

By rearranging it we get the following useful expression

$$\left[p^M\frac{\partial X_j^M}{\partial M_j}+w^n\frac{\partial L_j^M}{\partial M_j}\right]=\frac{1}{\lambda}\left(\frac{1+r}{1+\rho}\right)^j\frac{\partial U}{\partial M_j}+\frac{1}{\lambda}\sum_{v=j+1}^{n}\frac{(1+r)^j}{(1+\rho)^v}\frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$
$$+p^A+p^A\sum_{v=j+1}^{n}\frac{(1+r)^j}{(1+r)^v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j} \quad (26)$$

By comparing expressions (25) and (26) with previously derived expressions (19) and (20), we notice a striking similarity among them. Notice first that an element $p^A(\partial M_j/\partial L_j^M)$ in the first bracket in expression (25) presents the value of marginal product of labor, which increases with j and which is equal to the wage paid for artistic work. Formally,

$$p^A\frac{\partial M_j}{\partial L_j^M}=w_j^M$$

Bearing that in mind we conclude that the first part of expression (25) is equal to the first part of expression (19). It is intuitively clear, but it can be formally proved, that the same equality exists among the second part of expression (25) and the second part of expression (19). They present an expected value of increases of earnings from $j+1$ year to the end of the artist's career, caused by unit production in a year j and given in the present value in a year j. Finally, the third parts of compared equations are equal by definition, and they present expected streams of nonmonetary benefit increases that unit production in a year j generates to the end of the artist's career. Looking at expression (26) we see that its left hand side again presents the shadow price of a unit of commodity produced in a year j. The right hand side of this expression presents as before a stream of all benefits generated by a unit of commodity M_j up to the end of the artist's career. To conclude, expressions (25) and (26) have the same meaning as already discussed expressions (19) and (20) and their implication will be considered together in the next section.

5. Implications

As we already noticed, expressions (20) and (26), a stream of benefits generated by producing a commodity of art is much larger than that of ordinary goods, Z_j, implied by expression (18). As a consequence, artists will be motivated to allocate relatively much greater part of their resources in art rather than in ordinary commodities, Z_j. The same can be seen by looking at expression (19) and (25) and comparing them with expression (18). As we see, expression (19) differs from expression (18) for ordinary commodities by three additional parts. Firstly, the value of labor resources used in production of art $\frac{w^n}{\partial M_j / \partial L_j^M}$ given in the bracket is reduced by the value of an artist's earnings from artistic work $\frac{w_j^M}{\partial M_j / \partial L_j^M}$. The similar effect is present in Throsby's model (Throsby (1994b)). Secondly, the shadow price of producing a commodity of art is further reduced by the value of a stream of increases of future wages caused by arts unit production in a year j, $\lambda \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v} L_v^M \frac{dw_v^M}{dM_j}$. Finally, it is also reduced by the value of a stream of increases of future nonmonetary benefits caused by arts unit production and consequent human capital creation in a year j, $\sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v} \frac{\partial U}{\partial M_v} \frac{\partial M_v}{\partial H_v} \frac{dH_v}{dM_j}$. The last two effects are not present in Throsby's work preference model. Similar conclusions follow from examination of expression (25).

As a consequence, the marginal rate of substitution (MRS) between the commodity Z_j and the commodity M_j, given by

$$MRS = -\frac{\Delta Z_j}{\Delta M_j} = \frac{\frac{\partial U}{\partial M_j}}{\frac{\partial U}{\partial Z_j}}$$

$$= \frac{\lambda \left(\frac{1+\rho}{1+r}\right)^j \left[\frac{p^M}{\frac{\partial M_j}{\partial X_j^M}} + \frac{w^n - w_j^M}{\frac{\partial M_j}{\partial L_j^M}} \right] - \lambda \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v} L_v^M \frac{dw_v^M}{dM_j} - \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+\rho)^v} \frac{\partial U}{\partial M_v} \frac{\partial M_v}{\partial H_v} \frac{dH_v}{dM_j}}{\lambda \left(\frac{1+\rho}{1+r}\right)^j \left[p^Z \frac{dX_j^Z}{dZ_j} + w^n \frac{dL_j^Z}{dZ_j} \right]}$$

will be at the point of optimum much smaller than that of two ordinary goods. As a result, artists will devote much higher share of their resources to art than what will be the case if we suppose that M_j is another ordinary good. In fact, they will devote much more of their labor and other resources to arts than what Throsby's model (Throsby (1994b)) would suggest (see expression (4)). Two additional effects, not captured by Throsby's model, are responsible for it. The first one is the effect of expected stream of future monetary benefits (the second term in numerator). The second one is the effect of expected stream of future nonmonetary benefits (the third term in numerator). Although not present in Throsby's model, these effects are, in fact, in line with Throsby's sort of argument. They further strengthen the importance of nonmonetary benefits in explaining artists' pure market performance and earning penalties evidenced in numerous researches on artists' earnings. For more detailed elaboration and analysis of artists' market performances see contributions of Alper and Wassall (2006), Towse (2006), Menger (2006), Menger (2002) and Throsby (2007).

Note, however, that it is not easy to say what would be the time pattern of $\partial U / \partial M_j$ and MRS during the artist's career. There is no reason to believe that it will be ever decreasing by the passage of time, as one might be prompted to conclude. Human capital creation resulting from art practicing has, in fact, two contradicting course of influence on these two values. On the one hand, it has ever decreasing influence on the first part of expressions (19) and (25) given in the bracket. This decreasing effect is twofold. Firstly, by the increase of j it is natural to expect an increase of an artist's human capital and consequent increase of the artist's wage from an artistic job, w_j^M. This, in turn, will cause a decrease of the shadow price of a commodity M_j, that is a decrease of the first part of expressions (19) and (25). Secondly, the constant increase of human capital by the passage of time will increase both marginal productivity of arts labor $\left(\partial M_j / \partial L_j^M\right)$ and marginal productivity of arts market goods $\left(\partial M_j / \partial X_j^M\right)$. This, in turn, will contribute to further decrease of the first part of expressions (19) and (25). As a consequence, older artists are by passage of time motivated to devote more resources to an artistic commodity and art production. Specifically, owing to this effect at the certain point of time in their career artists devote their entire working time to the artistic jobs. Formally speaking L_j^n becomes equal to zero, artists stop doing two kinds of jobs, and their total earning becomes equal to $L_j^M w_j^M$. Needless to say, this is what determines switching point that we mentioned previously. There is plenty of empirical evidence to support this effect.

On the other hand, younger artists are also motivated to invest much of their resources in practicing of art. Their shadow prices of an art commodity are reduced by the second and third element of expressions (19) and (25). These two parts, as already said, present expected streams of monetary and nonmonetary benefits increases that practicing of arts in a year j brings to artist up to the end of their career. Quite naturally, the younger the artist the higher this effect is. In the case of very old and experienced artists this effect can vanish indeed. This effect explains why young artists have such a strong drive for their profession, even though their wages from artistic work are very low. It seems safe to say that young artists have almost absolute preferences toward practicing of art once their basic needs are satisfied. This effect explains why young artists usually do two jobs, artistic as well as non-artistic, and why a great number of young artists experience poverty during their career. Paradigmatic, in that sense, is the story reported by Abbing (2004) according to which different financial subsidies and other programs of Dutch government to reduce poverty among creative painters were not followed by the reduction of poverty as expected but by two unexpected results both supporting Throsby's idea that young artists have almost an absolute preference toward art practicing once their basic needs are satisfied. Firstly, the introduction of different subsidies was followed by the reduction of time young artists devote to non-artistic works. Secondly, the number of artists increased by the passage of time after the introduction of programs. Both phenomena can, obviously, be explained by the income effect. Surprising is, however, a sharp influence of this effect at such a low level of income.

So, we have two contradicting sets of factors that have an influence on movement of $\left(\partial U / \partial M_j\right)$ and MRS during an artist's career. One of them, the current arts wage and productivity of resources used in art production, are the result of artist's "*history*" and it has a decreasing influence on movement of the above variables. The second set of factors, expected monetary and nonmonetary benefits, present the artist's "*future*" and it has an increasing influence on their movement. The answer to the question which of these two effects is stronger is an empirical one. What we know in that respect is the fact that young artists devote much more of their working time to non-artistic jobs than older artists. Older artists, in fact, very often, at the certain point of time, stop doing non-artistic jobs. Needless to say, the answer to this question will be different for different kinds of arts and for different artists due to the specific characteristics and circumstances.

Several hypotheses have been offered so far in explaining oversupply of arts labor and other peculiarities of arts labor market discussed at the introductory section of this paper. Let us see where theoretical models developed here belong and how they match with existing hypotheses.

The first hypothesis, as we already know, is the one proposed by Throsby (1994b) according to which dealing with arts, apart from monetary benefits, brings a huge amount of nonmonetary benefits to artists. The models developed here, as already noticed, strengthen this argument even more by adding an effect of expected stream of future nonmonetary benefits as a motive for dealing with arts. The expected stream of utility derived from artistic practice can, of course, take the form of pure pleasure derived from artistic work as such, as Throsby insists, but can also take the form of excitement from expected recognition by peers and artistic public in general, and even more importantly the form of expected nonmonetary benefits derived from self-discovery and self-actualization.

The second hypothesis is the one proposed long ago by Adam Smith and advocated recently as a possible explanation by Towse (2006). According to this explanation young people tend to enter artistic labor market too frequently because they overestimate their talent and likelihood of their future success. In other words oversupply of artists is a result of a special kind of presbyopia (opposite of myopia) that is inherent to young people. Models offered in this paper also allow for such an explanation. Once we understand future monetary and nonmonetary benefits not as exact ones, but rather as expected ones, and once we allow that these expectations can be, for some reasons, systematically overestimated, the models proposed here offer a room for such reinterpretation as well. Of course, this explanation fits perfectly to behavioral economics kind of argument which insists that in modeling human behavior we should use agent's real "cognitive framework" and not one which assume that human beings are perfectly rational. If so, our model should be modified to incorporate this realistic "cognitive framework"[41]. Whether there are grounds for above mentioned systematic overestimations of expectations in the case of artists is very debatable question, however, as Alper and Wassall (2006) noticed.

The third hypothesis is offered by Santos (1976), who claims that artists belong to a class of risk-taking workers who are willing to trade off a small chance of huge financial rewards for a much larger chance of low earnings. By dealing with expected streams of earnings models offered in this paper can be used as a framework for this kind of thinking as well. Santos's hypothesis can explain high variations in earnings of artists, as well as excess supply of arts labor. However, it cannot explain earning penalties that characterize artists' earnings. Even more importantly, Santos does not explain why artistic occupations would attract such a disproportionate number of risk-takers.

The forth hypothesis can be interpreted as the one which insists that artistic occupations do not attract a disproportionate number of risk-takers but a disproportionate number of self-actualization-seekers. Self-actualization and self-discovery are characterized by permanent learning by doing and permanent search for innovations. This is not possible within routine activities that characterize ordinary jobs. Uncertainty is *sine qua non* for such kind of persuasion. As we know, there is plenty of uncertainty and plenty of possibilities for satisfaction of this motive in all kinds of artistic occupations. It is, therefore, neither presbyopia nor risk-seeking behavior that explains an artist's occupational choice, but rather a fact that uncertain artistic occupations offer plenty of possibilities for self-actualization. This idea, which also has long history - Aristotle, Hegel, Marx - has recently been advocated most prominently by Menger (2006). The models developed here fit perfectly with this important explanation: what we call expected stream of future non-monetary benefits refers mostly to artists' need for self-actualization and self-discovery.

Finally, the last hypothesis is the one that can be derived from the theory on the earnings of superstars (Rosen (1981), Adler (1985) and Adler (2006)). Unlike the second and third hypothesis this one is able to provide the explanation for earning penalties as well as for huge variations in artists'

[41] For most recent and detailed survey and references on Behavioral Economics see Angner and Loewenstein (2012).

earnings and excess supply of arts labor. Superstars in arts, sports etc. are individuals who are able to attain enormous success in their profession and whose earnings are significantly greater than that of their competitors. Rosen (1981) claims this phenomenon to be the result of interaction of two factors, one on the demand side and the other on the supply arts side. On the demand side of the story there is a hierarchy of talent and preference of consumers to consume the most talented artist. On the supply side there is nearly perfect (costless) reproducibility of art (especially performing arts) that occurs as a result of technological advancement (CDs for example). In those circumstances every consumer is able to consume the best art, while the most talented artist is able to capture the whole market. This is known as a winner-take-all situation[42]. Adler (1985), Adler (2006) proved that existence of superstars cannot be explained solely by differences in talent. According to his explanation there are a lot of artists who poses a stardom-quality talent. What produces superstars is the need on the side of consumers to consume the same kind of arts that other consumers do. This need develops from the fact that consumption of art is not momentary experience but a dynamic process that is based on previous artistic experience and knowledge accumulated in that way. This accumulation of knowledge is, however, not a result of consumers own ability to learn and judge about an intrinsic value of artistic products. Rather, it is a result of a complex social interaction and social processes able to induce path dependency phenomenon in the consumption of art. Owing to Adler's amendments a theory of superstar becomes relevant not only for performing but also for creative arts as well. No doubt, the theory of superstar has a path-breaking importance in explaining peculiarities of arts labor market. It, however, does not contradict with the explanation offered here. On the contrary, two explanations are complementary. The stardom explanation is about the demand side of arts labor market. The explanation offered here is about the supply side of that market: it explains why some people indulge in such a peculiar market at all.

The models proposed in this paper can also be regarded as more general because they can describe not only behavior of artists but also behavior in all those cases where work itself brings pleasure to workers, as well as in all those cases where previous activities has influence on current shadow prices of commodities. Art is only a paradigmatic case in which these widespread phenomena are most obvious and easy to understand. The work of scientists is also a very obvious case although they rarely experience a poverty stage during their career as artists do. Consequently, non-scientific working time of scientists is equal to zero almost from the beginning of their career. Their time earning profiles can prove, however, that expected stream of monetary benefits, the last part of expression (20), plays an important role in explaining their behavior in the early ages of their career. More importantly, their readiness to accept much lower wage rates compared to those in consulting or R & D activities within companies can be easily explained by the fact that their stream of nonmonetary benefits, the first and second part of expression (20), is significant indeed. In fact, it is so significant that it becomes decisive for their decision to deal with science. No doubt, a lot of scientific results, which are crucial for the growth of our standard of living, are paid by the mere pleasure that scientists derive from their work. The same applies to journalists especially those dealing with investigative journalism. There are, no doubt, a lot of other professions that can and should be analyzed in a similar manner. What is more important, it seems that, as a result of technological advancement, the number of such professions is growing. Technological progress has dramatically increased, and it is expected to increase even more, demand for so called creative works. The models developed here can be used for the analysis of a creative worker's behavior in general.

Another interesting phenomenon that can be explained using the above models is nonpaid work of volunteers. In many cases volunteers' readiness to work for free can be simply explained by the stream of nonmonetary benefits that such engagements bring to them. In most of the cases, however, other reasons may be even more important. The work of volunteers is very often explained by the fact that working as volunteers in the field of your own profession, while living from the income earned by

[42] One interesting empirical research testing winners-take-all hypothesis on DVDs market has been done recently by Walls (2009b). See also empirical researches of Mckenzie (2010), Nelson *et al.* (2007), Jozefowicz *et al.* (2008), Walls (2009a) and Pitt (2010).

doing some other job can help you develop your profession and your CV to the level that can help you get a position in your own preferred field of work. This in turn is supposed to increase your future monetary earnings as well as your future nonmonetary benefits.

Currently, volunteering work of professionals is not such a widespread phenomenon as it might become in the future according to some analysts. On the contrary, what we experienced in the last three decades within developed countries is a constant increase of wage premium paid to skilled labor (college graduates and above). This has occurred in spite of the fact that a share of skilled labor has increased dramatically. The most convincing explanation offered so far is the one according to which, due to skill-biased technological progress, demand for skilled workers has increased even faster than the supply of them (Krusell *et al.* 2000). If the supply of skilled labor continues to grow at the existing rate and if, due to creative-labor-biased technological progress that seems started by nineties, the demand for labor shifts more toward creative than simply skilled labor, we may easily find ourselves in the position of experiencing excess supply of skilled labor. In that case volunteering work among professionals might become widespread indeed. Volunteering may become an important screening mechanism for unveiling creative abilities of young professionals. In general, the whole market for professionals might take characteristics that are now regarded to be exclusive peculiarities of arts labor market.

Even more interestingly, technological progress is, at the same time, making all types of jobs easier to work. Galor and Weil (1993) developed the growth model that stylizes the facts that since the end of the sixties female participation in labor force and female wage rates have been growing relative to males. Those processes are explained by the fact that technological progress in the last half of the twentieth century reshaped requirements for almost all kinds of jobs by reducing dramatically “masculine” requirements and by increasing ”brain” requirements, making, in that way, almost all jobs affordable to females and, consequently, increasing supply of labor in developed economies. To say that “masculine” requirements are reduced is somehow the same as to say that disutility of work is reduced. Disutility of work, on the other hand, is nothing but negative value of what we call pleasure from work. More formally it is a negative value of the first part of our expression (20) and (26) $\frac{1}{\lambda}\left(\frac{1+r}{1+\rho}\right)^{j}\frac{\partial U}{\partial M_{j}}$. By allowing this element to be negative as well as positive the models developed here become even more general and able to explain a much wider span of economic and social phenomena than what its’ title suggest. Needless to say, apart from heaviness of work, there are a lot of other sources of disutility of work, like working conditions, ecological environment and similar. Of course, in these particular cases wages of non-pleasurable occupations should be larger than wages of alternative less difficult occupations. Mj can and should, in that case, be treated as “bad” or “discommodity”. A difference between wages of more unpleasant and less unpleasant works presents equalizing differences in the sense explained by Rosen (1987). Note, however, that in our case wage differences can compensate not only for current differences in disutility of work, but also for differences in expected stream of disutility, the second part of expressions (20) and (26) that may be caused by current work. The expected stream of disutility may, for example, take a form of deteriorated quality of life resulting from health problems induced by inadequate working conditions.

There are probably a lot of other interesting cases where proposed models can be used. We mentioned just these that seem to be most interesting and easiest to understand.

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APPENDIXES

6.1. A dynamic model with arts labor hired

The artist's decision making process is given by the following expression

$Uf = \sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^{j} U\left[M_j, Z_j\right]$ which should be maximized under the following full income constraint

$$\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M\right] = \sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[w_j^M L_j^M + w^n L_j + b_j\right]$$

such that $M_j = M\left[X_j^M, L_j^M, H_j\right]$, $Z_j = Z\left[X_j^Z, L_j^Z\right]$, $H_j = h\left[M_{j-1}, M_{j-2}, M_{j-3}, ..., E_j\right]$ and $w_j^M = w^M\left(H_j\right)$.

In order to solve the problem we form the following Lagrange:

$$\mathrm{L} = \sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^{j} U\left[M_j, Z_j\right] - \lambda\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M - w_j^M L_j^M - w^n L_j - b_j\right]$$

Since X_j^Z and L_j^Z are here derived from the expression $Z_j = Z\left[X_j^Z, L_j^Z\right]$, it follows that X_j^Z and L_j^Z are both the function of Z_j. On the other hand, since X_j^M and L_j^M are both derived from the expression $M_j = M\left[X_j^M, L_j^M, H_j\right]$, it follows that X_j^M and L_j^M are both the function of M_j, M_{j-1}, M_{j-2} and all other previous M. As we already know w_j^M is the function of H_j, which is, in turn, according to the expression of H_j, also the function of all previous M.

The solution of the problem is straightforward. The first order condition requires that partial derivatives of Lagrange with respect to M_j and Z_j be equal to zero. For the sake of simplicity, the second order condition will be skipped in the following consideration[43]. Using the described procedure we get the following solution for a commodity Z_j By the first order condition for Z_j we have

$$\frac{\partial \mathrm{L}}{\partial Z_j} = \left(\frac{1}{1+\rho}\right)^{j}\frac{\partial U}{\partial Z_j} - \lambda\left(\frac{1}{1+r}\right)^{j}\left[p^Z\frac{dX_j^Z}{dZ_j} + w^n\frac{dL_j^Z}{dZ_j}\right] = 0$$

Hence, we get the following solution for a commodity Z_j

$$\frac{\partial U}{\partial Z_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^{j}\left[p^Z\frac{dX_j^Z}{dZ_j} + w^n\frac{dL_j^Z}{dZ_j}\right] = \lambda\left(\frac{1+\rho}{1+r}\right)^{j}\pi_{Z_j}$$

[43] The second order condition requires that the second partial derivatives of the utility function with respect to M_j and Z_j be negative.

where $\pi_{Z_j} = p^Z \frac{dX_j^Z}{dZ_j} + w^n \frac{dL_j^Z}{dZ_j}$ presents the shadow price of a commodity Z_j.

By the first order condition for M_j we have

$$\frac{\partial L}{\partial M_j} = \left(\frac{1}{1+\rho}\right)^j \frac{\partial U}{\partial M_j} - \lambda\left(\frac{1}{1+r}\right)^j p^M \frac{\partial X_j^M}{\partial M_j} - \lambda\left(\frac{1}{1+r}\right)^j w^n \frac{\partial L_j^M}{\partial M_j} + \lambda\left(\frac{1}{1+r}\right)^j w_j^M \frac{\partial L_j^M}{\partial M_j}$$
$$-\lambda \sum_{v=j+1}^{n}\left(\frac{1}{1+r}\right)^v p^M \frac{dX_v^M}{dM_j} - \lambda \sum_{v=j+1}^{n}\left(\frac{1}{1+r}\right)^v w^n \frac{dL_v^M}{dM_j} + \lambda \sum_{v=j+1}^{n}\left(\frac{1}{1+r}\right)^v w_v^M \frac{dL_v^M}{dM_j}$$
$$+\lambda \sum_{v=j+1}^{n}\left(\frac{1}{1+r}\right)^v L_v^M \frac{dw_v^M}{dM_j} = 0$$

Hence, we get the following solution for M_j $\frac{\partial U}{\partial M_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^j \left[\frac{p^M}{\frac{\partial M_j}{\partial X_j^M}} + \frac{w^n - w_j^M}{\frac{\partial M_j}{\partial L_j^M}}\right]$

$$+\sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v}\left[\lambda p^M \frac{dX_v^M}{dM_j} + \lambda\left(w^n - w_v^M\right)\frac{dL_v^M}{dM_j} - \lambda L_v^M \frac{dw_v^M}{dM_j}\right]$$

In order to get more meaningful result we need to make some further transformations. We will use an alternative way of solving the above decision making problem. We first substitute production function M_j and Z_j in utility function U_f. This utility function is supposed to be maximized subject to the full income constraint. Lagrange now takes the following form

$$V = \sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^j U\left[M\left[X_j^M, L_j^M, H_j\right], Z\left[X_j^Z, L_j^Z\right]\right]$$
$$-\lambda \sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^j \left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M - w_j^M L_j^M - w^n L_j - b_j\right]$$

By solving for the first order condition, that is by equating partial derivatives of this Lagrange with respect to $X_j^Z, L_j^Z, X_j^M, L_j^M$ and H_j to zero, we get a set of equations from which we can derive expressions

$$\lambda p^M = \left(\frac{1+r}{1+\rho}\right)^j \frac{\partial U}{\partial M_j} \frac{\partial M_j}{\partial X_j^M}$$

and

$$\lambda\left(w^n - w_j^M\right) = \left(\frac{1+r}{1+\rho}\right)^j \frac{\partial U}{\partial M_j} \frac{\partial M_j}{\partial L_j^M}$$

These expressions are valid for every j and, therefore, for every v and that is exactly what we need for our further transformations.

By substituting this in the last part of the solution for M_j we get

$$\frac{\partial U}{\partial M_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^j \left[\frac{p^M}{\frac{\partial M_j}{\partial X_j^M}} + \frac{w^n - w_j^M}{\frac{\partial M_j}{\partial L_j^M}}\right] - \lambda \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v} L_v^M \frac{dw_v^M}{dM_j}$$

$$+ \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v} \frac{\partial U}{\partial M_v}\left[\frac{\partial M_v}{\partial X_v^M}\frac{dX_v^M}{dM_j} + \frac{\partial M_v}{\partial L_v^M}\frac{dL_v^M}{dM_j}\right]$$

Since $\frac{dM_v}{dM_j} = 0$ it is obvious that $\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j} + \frac{\partial M_v}{\partial L_v^M}\frac{dL_v^M}{dM_j} + \frac{\partial M_v}{\partial X_v^M}\frac{dX_v^M}{dM_j} = \frac{dM_v}{dM_j} = 0$

Hence, $\frac{\partial M_v}{\partial L_v^M}\frac{dL_v^M}{dM_j} + \frac{\partial M_v}{\partial X_v^M}\frac{dX_v^M}{dM_j} = -\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$

By substituting this result in the solution for M_j, we finally get

$$\frac{\partial U}{\partial M_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^j \left[\frac{p^M}{\frac{\partial M_j}{\partial X_j^M}} + \frac{w^n - w_j^M}{\frac{\partial M_j}{\partial L_j^M}}\right] - \lambda \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v} L_v^M \frac{dw_v^M}{dM_j}$$

$$- \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v} \frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$

By rearranging it we get an equally useful expression

$$\left[p^M \frac{\partial X_j^M}{\partial M_j} + w^n \frac{\partial L_j^M}{\partial M_j}\right] = \frac{1}{\lambda}\left(\frac{1+r}{1+\rho}\right)^j \frac{\partial U}{\partial M_j} + \frac{1}{\lambda}\sum_{v=j+1}^{n} \frac{(1+r)^j}{(1+\rho)^v}\frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$

$$+ w_j^M \frac{\partial L_j^M}{\partial M_j} + \sum_{v=j+1}^{n} \frac{(1+r)^j}{(1+r)^v} L_v^M \frac{dw_v^M}{dM_j}$$

6.2. A Dynamic Model with Arts Products Sold

The artist's decision making process is given by the following expression

$Uf = \sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^j U\left[M_j, Z_j\right]$ which should be maximized under the following full income constraint

$$\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^j \left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M\right] = \sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^j \left[p^A M_j + w^n L_j + b_j\right]$$

such that $M_j = M\left[X_j^M, L_j^M, H_j\right]$, $Z_j = Z\left[X_j^Z, L_j^Z\right]$, $H_j = h\left[M_{j-1}, M_{j-2}, M_{j-3}, ..., E_j\right]$ and $w_j^M = w^M\left(H_j\right)$.

In order to solve the problem we form the following Lagrange

$$
\begin{aligned}
\mathrm{L} = &\sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^{j} U\left[M_j, Z_j\right] \\
&-\lambda\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M - p^A M_j - w^n L_j - b_j\right]
\end{aligned}
$$

The same as before, since X_j^Z and L_j^Z are here derived from the expression $Z_j = Z\left[X_j^Z, L_j^Z\right]$, it follows that X_j^Z and L_j^Z are both the function of Z_j. On the other hand, since X_j^M and L_j^M are both derived from the expression $M_j = M\left[X_j^M, L_j^M, H_j\right]$, it follows that X_j^M and L_j^M are both a function of M_j, M_{j-1}, M_{j-2} and all other previous M.

The first order condition for the solution of the problem requires that partial derivatives of Lagrange with respect to M_j and Z_j be equal to zero. For the sake of simplicity, we again skip consideration of the second order condition. Using the described procedure we get the solution for commodity Z_j which is exactly the same as the one obtained previously in expression (18). As we know, the marginal utility of commodity Z_j should be equal to the marginal cost of all inputs involved in production of that commodity, which is equal to the shadow price of commodity Z_j.

By the first order condition for M_j we have

$$
\begin{aligned}
\frac{\partial \mathrm{L}}{\partial M_j} = &\left(\frac{1}{1+\rho}\right)^{j}\frac{\partial U}{\partial M_j} - \lambda\left(\frac{1}{1+r}\right)^{j} p^M \frac{\partial X_j^M}{\partial M_j} - \lambda\left(\frac{1}{1+r}\right)^{j} w^n \frac{\partial L_j^M}{\partial M_j} + \lambda\left(\frac{1}{1+r}\right)^{j} p^A \\
&-\lambda\sum_{v=j+1}^{n}\left(\frac{1}{1+r}\right)^{v} p^M \frac{dX_v^M}{dM_j} - \lambda\sum_{v=j+1}^{n}\left(\frac{1}{1+r}\right)^{v} w^n \frac{dL_v^M}{dM_j} = 0
\end{aligned}
$$

Hence, we get the following solution for M_j

$$
\frac{\partial U}{\partial M_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^{j}\left[p^M \frac{\partial X_j^M}{\partial M_j} + w^n \frac{\partial L_j^M}{\partial M_j} - p^A\right] + \sum_{v=j+1}^{n}\frac{(1+\rho)^j}{(1+r)^v}\left[\lambda p^M \frac{dX_v^M}{dM_j} + \lambda w^n \frac{dL_v^M}{dM_j}\right]
$$

In order to make this solution more understandable we will further transform it. We will use, again, an alternative way of solving the above decision making problem. We first substitute the production function M_j and Z_j in utility function U_f. This utility function is supposed to be maximized subject to the full income constraint. Lagrange now takes a new form

$$
\begin{aligned}
\mathrm{V} = &\sum_{j=1}^{n}\left(\frac{1}{1+\rho}\right)^{j} U\left[M\left[X_j^M, L_j^M, H_j\right], Z\left[X_j^Z, L_j^Z\right]\right] \\
&-\lambda\sum_{j=1}^{n}\left(\frac{1}{1+r}\right)^{j}\left[p^Z X_j^Z + p^M X_j^M + w^n L_j^Z + w^n L_j^M - p^A M_j - w^n L_j - b_j\right]
\end{aligned}
$$

By solving for the first order condition, that is by equating partial derivatives of this Lagrange with respect to $X_j^Z, L_j^Z, X_j^M, L_j^M$ and H_j to zero, we get a set of equations from which we can derive expressions

$$\lambda p^M = \left(\frac{1+r}{1+\rho}\right)^j \frac{\partial U}{\partial M_j}\frac{\partial M_j}{\partial X_j^M} + \lambda p^A \frac{\partial M_j}{\partial X_j^M}$$

and

$$\lambda w^n = \left(\frac{1+r}{1+\rho}\right)^j \frac{\partial U}{\partial M_j}\frac{\partial M_j}{\partial L_j^M} + \lambda p^A \frac{\partial M_j}{\partial L_j^M}$$

These expressions are valid for every j and, therefore, for every v and that is exactly what we need for our further transformations.

By substituting this in the last part of the solution for M_j we get

$$\frac{\partial U}{\partial M_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^j \left[p^M \frac{\partial X_j^M}{\partial M_j} + w^n \frac{\partial L_j^M}{\partial M_j} - p^A\right]$$
$$+\sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+\rho)^v}\frac{\partial U}{\partial M_v}\left[\frac{\partial M_v}{\partial X_v^M}\frac{dX_v^M}{dM_j} + \frac{\partial M_v}{\partial L_v^M}\frac{dL_v^M}{dM_j}\right]$$
$$+\lambda p^A \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v}\left[\frac{\partial M_v}{\partial X_v^M}\frac{dX_v^M}{dM_j} + \frac{\partial M_v}{\partial L_v^M}\frac{dL_v^M}{dM_j}\right]$$

Since expressions in the second and third brackets are the same and equal to:

$$\frac{\partial M_v}{\partial L_v^M}\frac{dL_v^M}{dM_j} + \frac{\partial M_v}{\partial X_v^M}\frac{dX_v^M}{dM_j} = -\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$

By substituting this result in the solution for M_j, we finally get

$$\frac{\partial U}{\partial M_j} = \lambda\left(\frac{1+\rho}{1+r}\right)^j \left[\frac{p^M}{\frac{\partial M_j}{\partial X_j^M}} + \frac{w^n - p^A \frac{\partial M_j}{\partial L_j^M}}{\frac{\partial M_j}{\partial L_j^M}}\right]$$
$$-\lambda p^A \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+r)^v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j} - \sum_{v=j+1}^{n} \frac{(1+\rho)^j}{(1+\rho)^v}\frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$

By rearranging it we get the following useful expression

$$\left[p^M \frac{\partial X_j^M}{\partial M_j} + w^n \frac{\partial L_j^M}{\partial M_j}\right] = \frac{1}{\lambda}\left(\frac{1+r}{1+\rho}\right)^j \frac{\partial U}{\partial M_j} + \frac{1}{\lambda}\sum_{v=j+1}^{n} \frac{(1+r)^j}{(1+\rho)^v}\frac{\partial U}{\partial M_v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$
$$+p^A + p^A \sum_{v=j+1}^{n} \frac{(1+r)^j}{(1+r)^v}\frac{\partial M_v}{\partial H_v}\frac{dH_v}{dM_j}$$

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AN EMPIRICAL STUDY OF FACTORS AFFECTING INFLATION IN REPUBLIC OF TAJIKISTAN

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Abstract:

This paper investigates the core factors affecting the price level in Republic of Tajikistan during 2005 to 2012 by using 'auto regressive distributed lags' and Johansen-Juselius co-integration models. The empirical analysis is based on a dataset of demand pull and cost push inflation indicators. Our findings revealed that in the long run, exchange rate, world wheat prices, world oil prices and labor supply Granger cause the price level. Nevertheless, in the short run, only world wheat price and labor supply has significant impact. In case of demand pull inflation, in the long run, GDP gap, remittances inflow, and real wages are endogenously determined in the system as they significantly affect the price level. But in the short run, GDP gap, remittances inflow, broad money, government expenditure and real wages Granger causes the price level.

Furthermore, there is a bi-directional Granger causality between GDP gap and remittances inflow. Also, real wage Granger causes the government expenditures. The GDP gap Granger causes the real wage, implying the scenario that a major cause of under production is the low level of employment. Finally the price level also Granger causes the real wage, is a reflection of a negative relationship between them.

Keywords: inflation, Tajikistan, cost push, demand pull, ARDL, co-integration.

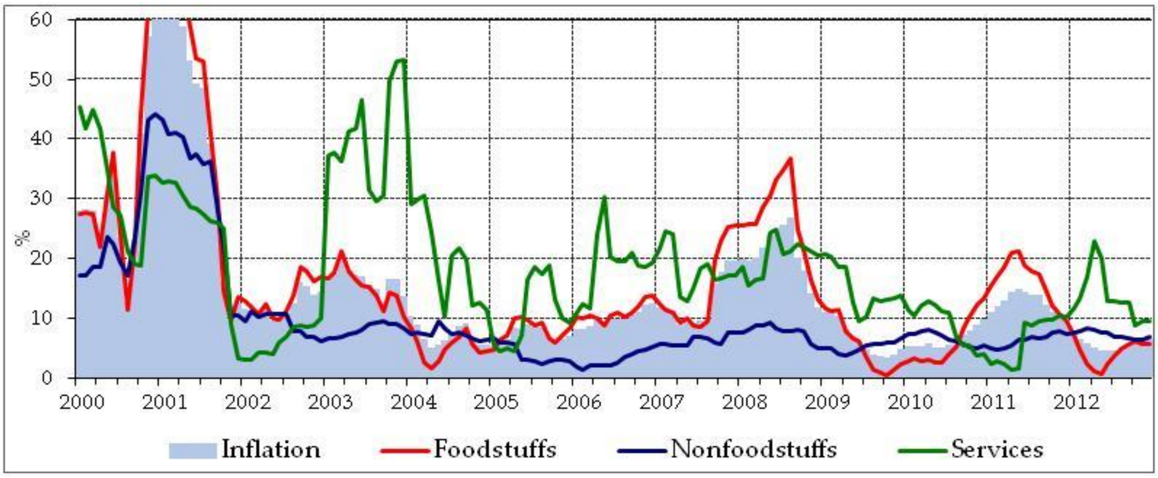
JEL Classification: E31.

1. Introduction

Throughout the post-Soviet era the actual challenges to the socio-economic stance of Republic of Tajikistan was unstable towards inflation as many other transition economies. The economic backwardness in Tajikistan had recorded two hyperinflation events: the first one was in April'93–December'93 when cumulative inflation was about 3,635.7% and during August'95–December'95, it showed 839.2% (Fischer, Sahay, and Vegh, 2002).

Fundamentally, the main causes of chronological high inflation till 2000 were political turmoil, unhealthy economic conditions, high fiscal deficits, administrative prices and incomplete reconstruction of the state enterprises. In addition, hyperinflation in the economy of Tajikistan attributed non-reliance of population to the domestic currency, financial system and further development of the economy. The vague course policy during the transition time led socio economic chaos and speed up price level astronomically. Nevertheless, the stabilization and liberalization policies for the economic rehabilitation had not been strong enough to avoid hyperinflation during the period under consideration.

It declares constantly that inflation had been reduced from double digit to single but if one looks at the historical trend of inflation in Republic of Tajikistan, the situation is quite reverse, as Republic of Tajikistan enjoyed only short episodes of lower inflation level. Specially, the price level of tradable goods in comparison with the non-tradable goods was more volatile, and contributed to the rising headline inflation process (Figure 1).



Source: (Author's compilation of National Bank of Tajikistan's data).

Figure 1. Fluctuation of Annual Inflation in the Republic of Tajikistan during 2000-2012. An increasing trend is significant during 2002-04 and slight decrease afterward

The volatility of inflation has exposed by the inertial supply and demand shocks. The fluctuations in World oil price have contributed a significant portion in the production costs both for food and non-food goods. It stimulates directly being a component of consumer basket for the measurement of inflation in the country. The prices of consumer goods push inflation upward because Wheat is a major item of Tajikistan's import and major portion of the consumer's basket consist food and energy items. It compounded 57.6% from which share of food products is 21.5% and energy 4.7% (Al-Eyd *et al.*, 2012). In addition, continues devaluation of domestic currency (Somoni) against the US dollar during the financial crisis was another factor for the sharp increase in the price level. Moreover, high remittance inflow gave an additional infusion to the behavior of consumers in the Tajik economy.

The tendency of evolution of inflation has some unfavorable internal and global economic conditions as shown in the following table (Table 1).

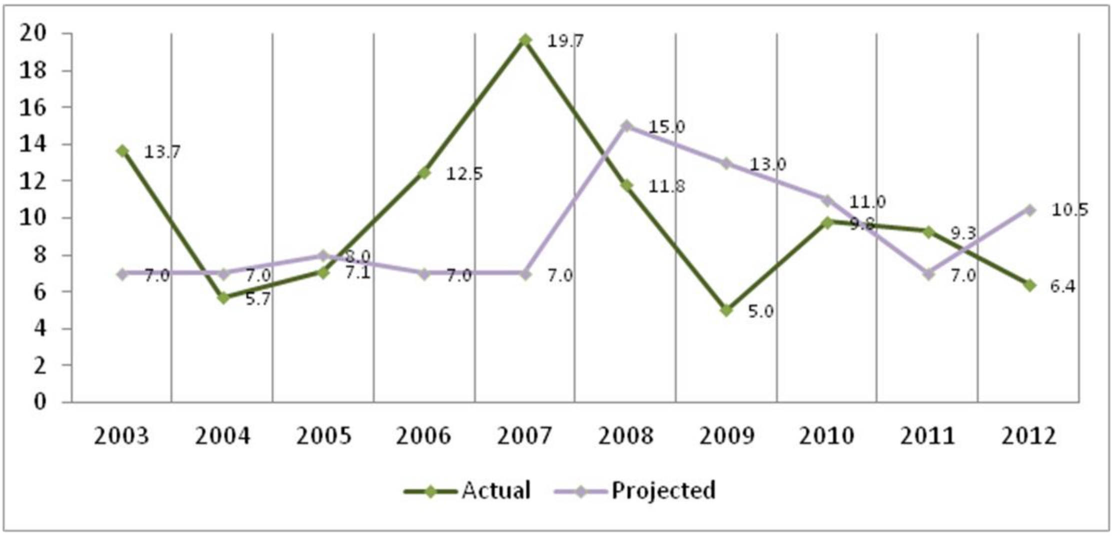
Table 1. Economic indicators of Tajikistan during 2005-2012

Indicators	Unit	2005	2006	2007	2008	2009	2010	2011	2012
GDP growth	(%)	6.7	7.0	7.8	7.9	3.9	6.5	7.4	7.5
State budget expenditure	(Million Somoni)	1403	1620	3475	5058	5643	6452	8254	9071
Budget (deficit) surplus	(Million Somoni)	12	38	221	282	(100)	101	242	525
Total labor resource	(Thousand People)	3893	4047	4210	4310	4435	4530	4664	4796
Employment	(Thousand People)	2112	2137	2150	2168	2219	2233	2249	2291
Trade (deficit) surplus	(Million USD)	(421)	(324)	(987)	(1863)	(1559)	(1463)	(1930)	(2419)
Exchange rate (average)	(Somoni / USD)	3.1166	3.2984	3.4425	3.4026	4.1427	4.3790	4.6102	4.7627
Broad money	(Million Somoni)	1027	1864	3327	3176	4275	5055	7131	8330

Source: (Author's compilation on the data of Banking Statistics Bulletin).

The proven danger attached with the volatility inflation as it discourages saving, investment and absorption of purchasing power. The frequent movements in inflation create an unfavorable economic condition by deterioration of businesses as well as consumers' confidence. Similarly, unexpected variation in inflation level begets its magnitude to jump high. Natural, spontaneous inflation changes, replace domestic currency to foreign currency in the public and financial operations, which is one of the original reasons of high dollarization level in Tajikistan. Under volatile inflation process, credit provided by financial institutions have short term, and to depict form an upfront barrier of high nominal interest rate in Tajikistan.

The National Bank of Tajikistan could not adopt inflation targeting regime, but its priority objective is to curb the price stability for the long term. In this regards, the monetary authority prognosis the rate for ensuring years, but the gap between projected and actual inflation was high (Figure 2).



Source: (Author's compilation on National Bank of Tajikistan's data).

Figure 2. The Gap of actual and projected inflation during the period 2003-2012

The multidimensional approach analysis of the inflation process and its speed encourage judging the discretion of economic policies for smoothing volatility of inflation. The inflation in Republic of Tajikistan was exported by various factors so the evaluation of specific episodes of problem would be relatively reliable guidelines for central bank's decisions.

The principle idea of this research is to determine the factors affecting inflation in Republic of Tajikistan during 2005-2012, by applying 'auto regressive distributed lags' (ARDL) model on the basis of cost-push and demand-pull inflation concepts. This study signifies the issue for prompt attention to the analysts and policymakers in Republic of Tajikistan and it will be relatively easy to explain political and economic causes of inflation in Tajikistan. The relevance of this study aims at comparing with previous studies on the relevant subject. The analytical consistency with theoretical concepts of inflation in case of transition economies makes it quite valid. The empirical models are developed according to the indigenous features of the national economic phenomenon in Tajikistan.

This paper is organized as follows. Section 2 includes the literature review of various points raised by other researchers. Section 3 addresses on theoretical background of inflation with controversial views of different schools of thought. Section 4 is based on empirical framework, data description and significant findings. Section 5 represents our conclusions.

2. Literature review

The literature survey consists on previous studies on determinants of inflation in Tajikistan and other transition economies. The limited empirical literature and scanty of analysis on the macroeconomic issues of Tajikistan depend upon the lack of availability of historical data, non-argumentative and inconsistent results of the analysis in the transformation of economic system and structural reforms. In general, the bulky dispute of studies focuses on the approach of an interrelated monetary inflation process in Tajikistan.

Zavkiev (2005) investigated both short run behavior of inflation and long run relationship of prices with their determinants. In the long run, prices are determined by exchange rate, money supply, real-output and interest rates. While in the short run, money supply, GDP growth and interest rate significantly affect the price level. He estimated a model of inflation by the instrumentality of the Johansen co-integration approach and single equation error correction model. The coefficient of adjustment for price level to its long-run equilibrium was high and also, the elasticity of price with respect to exchange rate is the second dominant long run factor affecting the inflation in Tajikistan. Other significant variables, such as real GDP and interest rates are semi-elastic in his conclusions.

On the same grounds Tashrifov (2005) uses the structural Vector Autoregressive (VAR) model to get the dynamic responses of inflation and output with monetary and exchange rate innovations in the economy of Tajikistan for the period 1996 - 2003. The main difference between the short-run and long-run restrictions of his models is that in the short run monetary and exchange rate innovations have a greater impact on variation in inflation, while in the long run these policy innovations are more effective in enhancing growth. Thus, the NBT's monetary and exchange rate policies have contributed significantly in attaining low inflation and high real output of Tajikistan's transitional economy between 1998 and 2003. On the basis of analyses, he concludes that transitional developing economies can adopt monetary and exchange rate policies (in particular money supply, interest rate and nominal exchange rate to attain a low level of inflation.

Recently in the empirical study conducted by Alturki and Vtyrina (2010) demonstrates the significant impact of broad money growth in determining inflation in both the short and long terms in Tajikistan. The analysis also shows the strong impact of the exchange rate and international inflation on local prices. They attributed various transmission mechanisms: interest rate, exchange rate and narrow credit channel by applying the Vector Error Correction Model (VECM) and Autoregressive Moving Average Model (ARMA). Though, they encouraged the limited ability to control the inflation by the National Bank of Tajikistan, and fragile effectiveness of monetary instruments such as inefficient interest rate channels for exerting inflation rate.

On the other hand, National Bank of Tajikistan in many analytical reports on 'Inflation Surveys' during 2009 to 2012, illustrated that non-monetary factors put pressure on prices and core inflation a tendency of stability. As antecedent, the core inflation is not involved in administrative/ tariff increase and seasonal as well as external factors. It composed of the modest change of prices for production under the influence of supply and demand in the domestic market (National Bank of Tajikistan, 2012).

Theoretically, the sources of inflations' phenomena exposure basically by the cost push effects and result of oil or food shocks. After 2007-2008 (Global Financial Crisis) an upsurge in global food and oil prices transmitted into higher domestic food prices in developing economies specially those depends heavily on imports, that is why, sensitivity of global prices in determination of volatility in domestic inflation becomes more relevant. The impact of external factors is substantial as the global food prices push domestic inflation to raise in the developing countries because in the measurement of a basket of consumer's good the share/ weight of food is high. During 2011, the international Wheat prices rose about 99.6% but the domestic prices in Tajikistan increased only 30%-40% (Al-Eyd and Amaglobeli, 2012).

Al-Eyd *et al.* (2012) investigate the implications of high global food prices on the price level in Central Asian countries including Tajikistan and concludes that Tajikistan's economy shows some significant short-run influence from the global commodity prices especially Wheat price shock. Their study based on (ARDL) model with seven lags and revealed that an increase in aggregate demand, nominal exchange rate depreciation, and global food prices have immediate convertibility on inflation. Moreover, there is an indication of weak institutional framework for monetary policy since monetary transmission appears limited at short horizons in this case. Similarly, the fiscal stance averted pressure on price. They recommend support price stability and guard against pro-cyclicality. A balanced approach is much needed to maintain the essential support to the vulnerable sectors of the society. Existing social safety nets should be employed to protect the most vulnerable groups from the pass-through of higher commodity prices.

Previous studies on inflation concerning with similar economic history, institutional structure and political conditions like Tajikistan allow us to shed light on the possible factors affecting to the upsurge inflation. As various factors revealed instability in price levels, a broad study on inflation with the virtue of multidimensional approach modeling are important for determining the disinflation tools.

After post communism period, shifting from administrative control to price liberalization system many transition economies faced a disease of hyperinflation due to bumpy and inconsistent policies. Nevertheless, the price stability still remains the absolute priority task of stabilization strategy, and some of the countries taking the inflation targeting framework as a satisfactory regime for lowering inflation performance and macroeconomic stability. On the other hand, the precondition economic stance makes irrepressible price volatility due to the exposure of external and internal shocks. In terms of economic specification, economic openness, institutional structure and financial development etc. provoke inflation inertia during the transitory period.

Adigozalov (2009) examines determinant of inflation in Azerbaijan during 2000-2009 by applying co integration modeling. The concept of the model targeted to capture external and internal factors of inflation such as broad money (M3), oil GDP and non-oil GDP, nominal effective exchange rate, credit and deposit rates. The empirical results show an appreciation of domestic currency has multiple effects on inflation. In addition, the elasticity of non-oil GDP is higher than the GDP of oil. Being an exporter of oil, Azerbaijan extract a boom in foreign asset inflow to the economy that affects to the exchange rate while domestic liquidity expansion reinforcing inflation process. The spillover effect of external factor, expressed as higher prices in trading partners and exchange rate depreciation, the lack of independent monetary policy with a combination of pegged exchange rate, contribute to inflation process in the long run. The short term inflation shock that exacerbated by supply side bottleneck manifested as production of long term determinants of inflation in Azerbaijan.

To investigate the impact of globalization and trade openness Meraj (2013) used ARDL approach within ECM-VAR framework and found a causal relationship between GDP and trade (exports and imports) and has positive impact of trade on economic growth in case of Least Developed Countries (LDCs). To study inflation in Georgia, Maliszewski (2003) uses the empirical analysis within the theoretical framework of aggregate demand and supply in three markets i.e. goods, exchange rate and money. He found a strong effect of exchange rate fluctuation on the price level, the behavior of money had also a significant effect in large lag period. The existing supply shocks in agriculture have a significant short-term impact, while import prices of oil have a relatively small impact on inflation. This scenario is common for dollarized and rapidly fluctuated demand for money in the transition economies. Accordingly, the economic history of a country's enduring hyperinflation provide serious challenges for price stabilization policy, considering that fact that general public remind the past event, and economy becomes very sensitive to external and internal shocks.

In the other research segments the variables on the basis of demand pull and cost push theories were driven a structural inflation function as an equilibrium error correction model (Leheyda, 2005). She used co-integration approach, which distinguishing the short-term and long-term effects and develop a general model that embeds with several hypotheses for inflation in Ukraine for the period 1997~2003. She found that in inflationary process the strong effect of exchange rate was in a lag of one month. The unit labor cost contributed in the short term inflation, money demand, purchasing power parity, foreign prices and mark-up relationships are the factors for long-run upsurge in the price. The Granger causality between the wages and prices uni-directionally runs from the wages to the prices. He proposed the exchange rate transmission mechanism instead of using the other channels like interest rate for the price stability.

Ranaweera (2003) by using an error correlation approach investigated the impact of disequilibrium in domestic markets and external shock on inflation in Uzbekistan for 1994-2000. The Uzbek economy specified the wide gap between the official and market exchange rate, imbalance in foreign exchange market. Nevertheless, the disequilibrium in market is not driven by the prices but foreign exchange market had significant influence on it. The imbalance in the product and money market also caused the price level to go up.

The structural co-integrating VAR has modeled by Kim (2001) to analyze the impact of monetary, labor and external sector to the inflation in Poland during 1990-1999. He pointed out that the labor and external sector are appreciable in inflation pressure. However, after 1994 they have inversely effected. The appreciation of national currency (Zloty) constrained inflation, while a cost push effect has driven excessive wage stimulation. The monetary sector had passive influence to the price fluctuation. He observed that Poland being a transition economy had initially high inflation (about 580% per annum in 1990) but after the successful implementation of stabilization programs for the price stability, the inflation rate significantly declined.

Pahlavani and Rahimi (2009) conducted a study to find the determinants of inflation in Iran by applying ARDL model. Their empirical model is based on the special economic peculiarity which includes variables as GDP, expected inflation, liquidity, imported inflation and the dummy variable presenting the effect of Iran/Iraq war on Iran's economy. The time series data has used for a period of 1971 to 2006. Their results explain that the liquidity, exchange rate, expected inflation rate and the rate of imported inflation granger cause inflation in the Iranian economy. Similarly, the war with Iraq continuing eight years had an effect on the inflation rate in Iran. The expected inflation has the most significant impact on inflation being an endogenous to the system. It stipulates structural challenges, transaction cost, and a lack of exchange market. The second endogenous factor impacted on price level is excessive liquidity which invoked budget deficits. Moreover, another determinant of inflation is the instability of exchange rate, which appeared through unification policy.

In a comparative study of inflation in Bangladesh and India over a period of 1979 -2010, Paul and Zaman (2013) used 'auto regressive distributed lag' (ARDL) approach and found the dominance of monetary effects after counter adjustments of supply shocks. In addition to it, their study reveals that the inflation rate was rapidly rose whenever the money supply grew in Bangladesh than in India, implying the scenario of an inconsistent pattern of money supply from the central banks of both countries. The inflation differential between India and Bangladesh is mainly due to the significant differential in money supply. They also shed light on Friedman's hypothesis that primary factors which affect inflation are monetary factors. The supply shocks were not explicitly expressed in the upsurge of price. The significance level of economic indicators i.e. remittances, world inflation and exchange rate were not high. The estimation did not show the effects of the output gap to the price level in both countries. The dummy variables in the analysis applied to capture the financial crisis of 1990 in India and the fuel price shock in 2008.

Many transitions and developing countries have adopted inflation targeting (IT) framework, restrained money supply and practiced pegged exchange rate regime for the purpose of minimizing the price volatility. However, one of the serious obstacles is a vulnerability to the external and domestic shocks, and limited monetary policy framework to combat with inflation phenomenon. The economies experienced hyperinflation in their past history has structural problems such as independence and transparency of the central banks. Notwithstanding, in consideration with the advantages of IT, an enhanced credibility of the economic policy, weaken the impact of inflation expectation and socioeconomic stability. The developing countries like Armenia, Georgia, Moldova, Albania and Ghana use IT as the anchor of their economic strategy. Similarly, the building blocks of inflation targeting improve inflation performance and have limited effects on trade-off between inflation and output. This point exhibits in the empirical study on the impact of IT to LIC by difference-in-difference and the propensity score matching approaches. The idea of this study is to define the behavior of economic indicators of inflation and real GDP. They test the inflation fluctuation and growth volatility before and after IT in 10 emerging markets and 29 less income countries who adopted the IT criteria. The results of their analysis revealed that in IT framework the inflation was less volatile, growth variability was not affected and there was very limited evidence of impact on economic growth (Gemayel, Jahan and Peter, 2011).

Worthwhile to note here that the economies who successfully achieved targeted inflation had antecedent macroeconomic stance such as healthy financial institution, developed financial markets, absence of fiscal dominance, independence of the central bank and effective working transmission mechanism. Another important element is existent technical infrastructure and methodology, including macroeconomic data for appropriate modeling, forecasting capability of monetary institute and forecasting ability of possible scenarios / determinant of inflation (Freedman and Ötker-Robel, 2010).

For an empirical investigation and detailed understanding of the determinants of inflation, the next section covers the theoretical background and reviews of various schools of thought.

3. Theoretical framework

Various economic scholars and practical experiences have justifies that inflation remains an actual problem for achieving socio-economic stability and long term economic development especially in transition economies. The restraint of inflationary pressure is the primary purpose of majority of the central banks.

Inflation is an inevitable property of any economy in the world. In fact, it is not a simple rising of the general price level but more complex natural economic phenomenon within a particular economic system. It is an indicator of a healthy economy and fall of the market value (Aurangzeb and Haq, 2012).

"The root of inflation is an endemic reaction of economic policies and diverse factors, and challenge in one of the direction of economy which interferes in price stability. To tackle the lack of consistency between fiscal, monetary and exchange rate policies, structural factors (such as the degree of capital mobility and the existence of wage and price inertia), credibility problems, and the stance of expectations regarding the policies" (Agenor and Montiel, 1999, p. 398). One of the shortcomings in macroeconomic policy is that it deteriorates the economic stability such as inflation volatility in the country. In this connection, investigation is useful in two strands together i.e. the effective policy and the theoretical statement. It is precious to note here that both strands are logical and clearly interlinked. Any stabilization policy should reflect the causal nexus associated with each particular evidential theory (Bastos, 2002).

The theoretical considerations formulated in terms of two aspects i.e. demand-pull and cost-push of inflation make a comprehensive and coherent summary of several explanations for the source of inflation in the short and long run. The controversies surrounding these two differentiated theories of inflation are based on the major debates of various orthodox competing schools of economics and their advocates. Notwithstanding, the stale concepts, they still keep actuality and widely used in empirical and theory implication by contemporary researchers.

Demand-Pull Approach: The traditional and most common type of inflation, generated by forced up inflationary pressures, driven through excess demand for goods and services made up the expression of components of aggregate demand. Initially the advocates of the classical school, Keynesian and Monetarist had devised the different principles to understand the demand pull inflationary process. According to the Keynesians, it is a result of income disturbances and shocks to the economy such as oil price increases or increase in other input factors. In contrast with, the Monetarists convince that it occurs because of excess aggregate demand and inappropriate monetary responses to the economic situations.

According to the Keynesian theory, the demand pull inflation can be interpreted as a positive relationship between inflation and output and negative with unemployment. Hence, an acceleration of employment results in increased aggregate demand, which leads to further hiring by the firms to meet the enhanced demand and to increase the output. But due to the capacity constraints increase in output will eventually become so small that the price of the goods will rise.

With general acceptance of demand pull mechanism is the Keynesian "inflation gap" model, which was originated by John Maynard Keynes (1940) and Arthur Smithies (1942). They explicitly indicate with special reference to the war effects. The integration of inflation pressure is neither the source of excess or "extra" demand nor any interest rate disequilibrium but the additional expenditure incurred by the governments. They posit that as the wages lag behind the prices inflation becomes a redistribution process for which some social class has to pay the income to fill the "inflationary gap".

The Keynesians school of thought, virtues the occurrence of demand-pull inflation as the lack of production capacity during the phase of excess aggregate demand under the assumption of full capacity utilization or a mismatch in speed of adjustment. On contrary, the Classical economists look at the change of aggregate money supply which serves for the transaction as a source of inflation. They argue that the accelerating money supply grows faster than the ability of the economy to supply the appropriate goods and services. For Monetarists, inflation is exclusively a monetary phenomenon arises from excessive demand. The concept points out in a perfectly competitive economy and in the absence of other externalities, market forces operate through the price mechanism. An optimum allocation of resources is assured when market clearing prices prevail. The Monetarists convince that the money supply is a "dominant, though not exclusive" factor which affects prices in both short-run and in long-run, and output in short run only.

Cost-Push Approach: The higher production costs and productivity maximized, companies cannot maintain the profit margins by producing the same amounts of goods and services. Consequently, the increased costs pass on to the final consumers, causes a rise in the general price level. The long term cost-push effect revives stagflation in the economy. One of the factor which affect the input pirces to jump up is the scacity of raw materials, abrupt increase in world prices, including oil and fuel prices. It also occurs due to the vulnerability to the external economic shocks such as commodity price volatility in the world market and the exchange rate depreciation. The increase in production costs put an inflationary pressure on the shoulders of firms because to hire highly qualified labor force the firms need to increase the wages but successfully tranfers this incidence of production cost to the consumers by raising their output prices.

When an economy approaches full employment the reserves of the unemployed gradually disappears which encourage the laborers and their representatives to demand an increase in their wages. In order to prevent this wage increase from eating into profits, employers subsequently raise their output prices and keep the mark-up intact. Eventually, the real wage brings down again to with higher food prices. A demand for real wage resistance leads to a wage-price spirals that propagate through the indexation mechanism. A supply-side shock sparks off a chronic inflation process in a fully employed economy. The depreciation of domestic currency could affect the price of imported goods such as foodstuff, raw materials and capital equipment especially in a small open economy considered to be a price-taker.

4. Empirical approach

A huge amount of past studies with large scale models explore the conceptual correspondence and empirical estimates to get the structural factors affecting the inflation trend. In this context, a specific economic theoretical study consideration allows the elucidating selection of the variables, which are relevant to spell out inflation within the selected approach. Various quantitative analyses of inflation and complicated approaches have been developed on the basis of the global and domestic economy. Sims (1980) criticized strongly in his macroeconomic models selection and provided the following disadvantages:

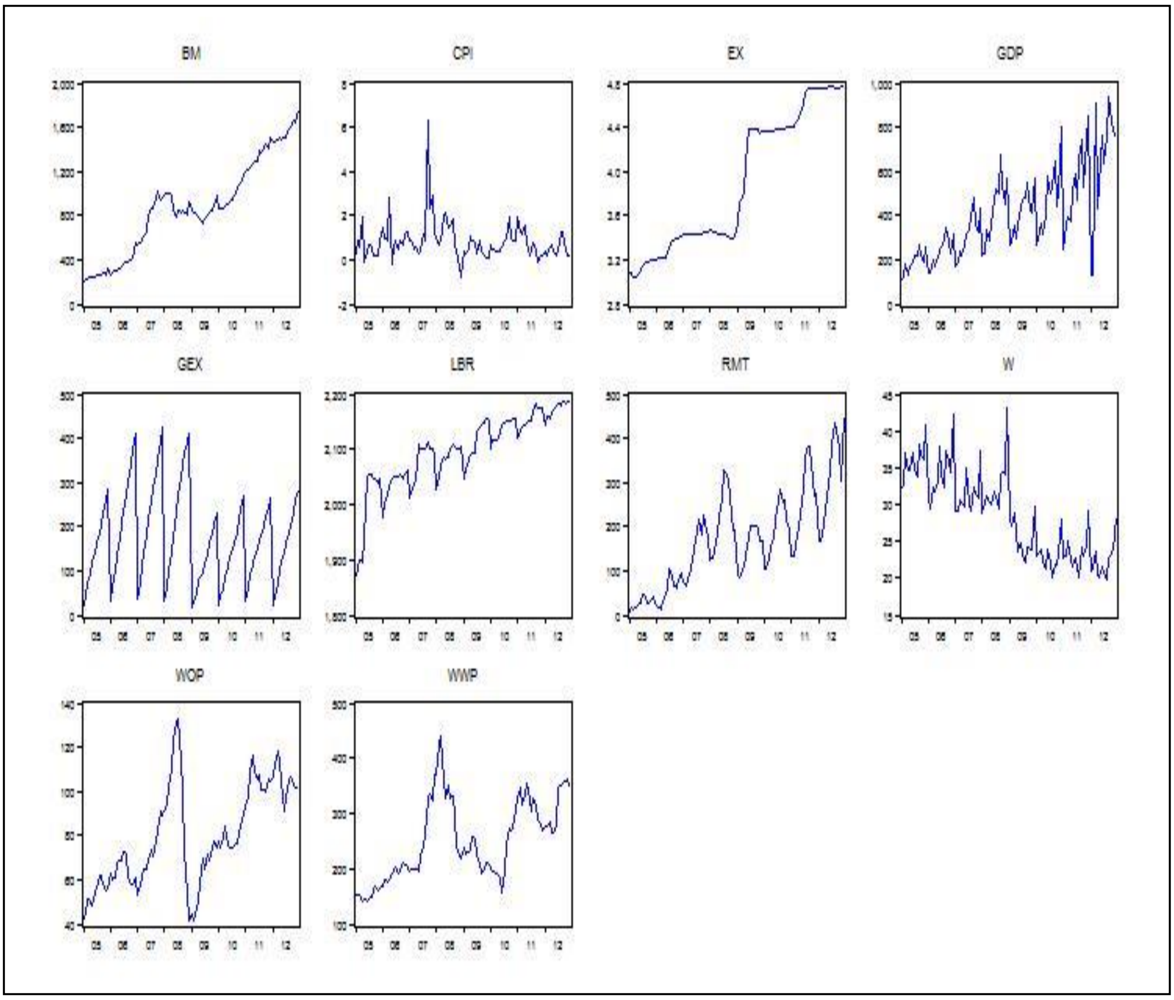
1) The economic theory is not rich enough to provide a dynamic specification that identifies all of the underlying relationships, and

2) The estimation and inference is complicated because endogenous variables may appear on both sides of the equations, causing simultaneity problems. Thus, vector auto regression (VAR) models are the most favorable method for the macro econometric in practice.

4.1 The data

The data set used in this study is of secondary nature and has been collected from various sources like National Bank of Tajikistan and WDI of the World Bank. It is a monthly data related to the factors affecting the price level (both demand and supply side). The dataset comprises consumer price index (CPI), world oil price (WOP), broad money (BM), exchange rate (EX), remittance-inflow (RM), real wage (RW), gross domestic product gap (GDP), world wheat price (WWP), government expenditure (GEX) and economically active population (LBR). The period under consideration is from January'2005 to December'2012; all values are in million U.S dollar except CPI.

We transformed all data series into natural logarithm to get more precise results. Microsoft Excel and econometric software package E-Views have used for the compilation of the data. Figure 3 below shows the graphical trend of all indicators over time.



Source: (Author's estimation).

Figure 3. The graphical pattern of all variables used in this study

(BM) represents broad money, (CPI) is consumer price index, (EX) is exchange rate, (GDP) represents output gap, (GEX) is government expenditure, (LBR) is a proxy for labor supplied and measured through economically active population. While, (RMT), (W), (WOP) and (WWP) represent inflow remittances, real wage, world oil prices and world wheat prices respectively. Since all variables are trending over time, the likelihood of co-integration between them is very high

Table 2. The descriptive statistics of the variables used in this study

	BM	CPI	EX	GDP	GEX	LBR	RMT	W	WOP	WWP
Mean	869.11	0.83	3.90	402.21	174.41	2,095.39	171.48	28.44	79.45	250.23
Median	863.81	0.70	3.50	359.47	163.71	2,101.40	166.35	29.01	74.81	235.43
Max	1,747.63	6.30	4.77	932.68	423.88	2,188.00	451.09	43.13	132.55	439.72
Min	208.15	-0.80	3.04	116.26	18.48	1,871.90	9.45	19.79	41.53	140.88
Std. Dev.	424.04	0.84	0.62	201.97	105.38	69.13	111.18	5.83	22.70	72.81
Skewness	0.12	3.18	0.18	0.73	0.50	-1.11	0.49	0.35	0.30	0.41
Kurtosis	2.10	20.23	1.35	2.75	2.47	4.45	2.54	2.18	2.11	2.18
Jarque-Bera	3.44	1,349.36	11.43	8.69	5.16	28.03	4.68	4.67	4.62	5.38
Probability	0.18	0.00	0.00	0.01	0.08	0.00	0.10	0.10	0.10	0.07
Sum	83,434.53	79.31	374.07	38,612.16	16,743.02	201,157.10	16,462.44	2,729.76	7,627.35	24,022.34
Sum Sq. Dev.	17,082,036.0	67.5	36.7	3,875,254.0	1,055,011.0	453,997.2	1,174,210.0	3,232.6	48,947.3	503,679.7
Observations	96	96	96	96	96	96	96	96	96	96

Source: (Author's estimation).

4.2 The models

To test the long run relationships between the indicators, one of the best methods in respect with the time series data is autoregressive distributed lag (ARDL) models. The co-integration analysis with ARDL may involve lagged values of the dependent variable, current and lagged values of one or more explanatory variables. This advantage of ARDL compares other regression models, in variables is to examine differing optimal number of lags and could be applied irrespective order of integration. The ARDL model has developed by Pesaran and Shin (1997) and further fine-tuned by Pesaran (2001).

Starting from the general form of auto regressive distributed lag is as below:

$$\Delta y_t = \beta_0 + \sum_{i=1}^{n} \beta_i \Delta y_{t-i} + \sum_{j=1}^{m} \gamma_j \Delta x_{t-j} + \psi ECT_{t-1} + \varepsilon_t \quad -----------(1)$$

As for this study we specify two different approaches i.e. one to capture the effects of the supply side determinants and the other to get the relationship of demand side factors with the price level. The ARDL is very convenient empirical tool for multidimensional diagnosis of the determinant catalyst of Tajik inflation with a various lags as well. The theoretical background guides in selection of endogenous of the models in two following approaches:

$$\Delta Lcpi_t = \gamma_0 + \sum_{i=1}^{n} \gamma_{1i} \Delta Lcpi_{t-i} + \sum_{i=1}^{n} \gamma_{2i} \Delta Lex_{t-i} + \sum_{i=1}^{n} \gamma_{3i} \Delta Lwwp_{t-i} + \sum_{i=1}^{n} \gamma_{4i} \Delta Lwop_{t-i} + \sum_{i=1}^{n} \gamma_{5i} \Delta Llbr_{t-i} + \alpha_1 Lcpi_{t-1} + \alpha_2 Lex_{t-1} + \alpha_3 Lwwp_{t-1} + \alpha_4 Lwop_{t-1} + \alpha_5 Llbr_{t-1} + \mu_t ------------(2)$$

With respect to referred proxy cost push effect, the combination of external supply shocks of global wheat prices (WWP), world oil price (WOP), and domestic factors like exchange rate (EX) and labor supply (LBR) are taken as regressors of through passed inflation in long and short terms. Tajikistan as an importer of wheat and oil remains very sensitive directly and indirectly through its effects on producer / wholesale price inflation to changes in global wheat and oil price. The exchange rate includes a possible capturing exogenous factor through a transmission channel of inflation.

Where Lcpi represents natural log of consumer price index, Lex is natural log of exchange rate, Lwwp is natural log of world wheat price, Llbr is a natural log of labor supply and Lwop is natural log of world oil price, while α and γ are parameters of estimation and μ is stochastic error term.

In proxy demand pulls an output gap (GDP), remittances (RM), real wages (RW) as consumer shock, government expenditure (GEX) and broad money (BM) as a possible monetary factor affecting to inflation rate are selected as endogenous of through passed inflation in the long and short period. The real wage basically has a spiral effect to demand and supply pressure on inflation. The remittances reviving demand pull of inflation.

To capture the demand side effects we specify the following model:

$$\Delta Lcpi_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta Lcpi_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta Lgdp_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta Lrmt_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta Lrw_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta Lbm_{t-i} + \sum_{i=1}^{n} \beta_{6i} \Delta Lgex_{t-i} + \phi_1 Lcpi_{t-1} + \phi_2 Lgdp_{t-1} + \phi_3 Lrmt_{t-1} + \phi_4 Lrw_{t-1} + + \phi_5 Lbm_{t-1} + \phi_6 Lgex_{t-1} + \varepsilon_t ---(3)$$

Where Lcpi represents natural log of consumer price index, Lgdp is natural log of output gap, Lrmt is natural log of remittance, Lrw is natural log of real wage, Lgex is a natural log of government expenditure and Lbm is natural log of broad money, β and ϕ are parameters of estimation and ε is random disturbance term.

4.3 Testing for order of integration

As a first step we check the order of integration in all of our variables because stochastic disturbance followed by the series of a non-stationary series does not allow converging to their long run average value. Therewith, a specious result is returned when we apply regression on non-stationary series to another non-stationary series. In order to test and convert our variables into stationary we used Augmented Dickey-Fuller and Phillips-Perron unit root testing procedures to our variables.

Table 3. Unit Root Testing through two major testing methods i.e. Augmented Dickey-Fuller and Phillips-Perron

Variables	Augmented Dickey-Fuller				Philips-Perron			
	At Level		Δ		At Level		Δ	
	Constant without Trend	Constant and Trend	Constant without Trend	Constant and Trend	Constant without Trend	Constant and Trend	Constant without Trend	Constant and Trend
Lbm	-1.812	-1.650	-10.380*	-10.529*	-1.792	-1.694	-10.377*	-10.500*
Lcpi	-4.099*	-4.414*	-9.853*	-9.867*	-4.125	-4.308	-11.761*	-12.623*
Lex	-1.178	-3.118	-3.185***	-3.177***	-0.670	-2.146	-5.311*	-5.289*
Lgdp	-2.835***	-0.942	-4.503*	-4.823*	-4.205*	-6.697*	-14.295*	-14.210*
Lgex[a]	-0.570	-1.789	-1.692	-1.619	-5.637*	-5.577*	-22.628*	-22.444*

Llbr	-3.252**	-4.741*	-3.166***	-3.149	-3.251**	-4.730*	-9.515*	-9.578*
Lrmt[a]	-2.175	-3.256	-1.969	-2.083	-2.546	-3.277**	-7.935*	-7.883*
Lrw[a]	-0.911	0.594	-2.406	-2.402	-2.869**	-6.290*	-17.284*	-17.199*
Lwop	-2.689***	-3.726**	-6.239*	-6.218*	-2.444	-2.923	-6.269*	-6.251*
Lwwp	-1.886	-2.263	-7.589*	-7.550*	-1.629	-1.998	-7.546*	-7.506*

Source: (Author's estimation).

[a]: significant at 1% level after second differencing in ADF

*, **, *** show 1%, 5% and 10% level

Note: Unit Root Testing in above table show that all the variables are non-stationary and become stationary after first differencing except government expenditures, Remittances inflow and real wage which requires double differencing to make them stationary.

Both 'augmented Dickey-Fuller' (ADF) and 'Phillips-Perron' (PP) tests confirm that all the variables are integrated of order 1 except lgex, lrmt and lrw which are integrated of order 2. In order to make I(I) variables stationary, first differencing is appropriate and for I(2) variables double differencing is required.

4.4 Testing for Co-integration

4.4.1 Model for capturing the determinants of cost push inflation

4.4.1.1. Johansen-Juselius Technique

After getting confirmation about the integration characteristics of our variables, we proceeds further, to test the co-integration between them. Two co-integration techniques have used in this study i.e. Johansen-Juselius (1990) and 'auto regressive distributed lag' (ARDL) developed by Pesaran-Smith (2001).

To test the co-integration between variables through Johansen-Juselius (1990) technique, it is required to establish a 'vector auto regression' (VAR) model, in order to identify the number of co-integrating vectors by trace and maximum Eigen value tests' statistics.

As a first step we identify the lag length in our VAR model through the specified criterion. 'likelihood ratio' (LR), 'final prediction error' (FPE), 'Akaike information criterion' (AIC), and 'Hannan-Quinn information criterion' (HQ) proposed two lags. Nevertheless, 'Schwarz information criterion' (SIC) suggests one lag. Initially we choose three lags on the basis of abovementioned criteria for the VAR model of this study.The trace test confirms that our time series is co-integrated (Table 4).

Table 4. Johansen Co-integration (Trace Test)

Hypothesized Co-integrating H_0	No. of Relationships H_1	Trace Statistic LR	5% Critical Value	1% Critical Value
r = 0	r > 0	126.131*	69.818	65.730
r ≤ 1	r > 1	65.491*	47.856	45.370
r ≤ 2	r > 2	23.703	29.797	28.80

Source: (Author's estimation); * indicates rejection of H_0 at 1% level. Likelihood ratio test (LR) confirms 2 co-integrating vector.

Table 5. Johansen Co-integration (Maximum Eigen Value Test)

Hypothesized Co-integrating H_0	No. of Relationships H_1	Max-Eigen Statistic	5% Critical Value	1% Critical Value
r = 0	r > 0	60.639*	30.31	35.60
r ≤ 1	r > 1	41.788*	23.97	28.65
r ≤ 2	r > 2	19.168	18.04	22.41

Source: (Author's estimation); * indicates rejection of H_0 at 1% level. Max-Eigen Value test indicates 2 co-integrating vectors.

4.4.1.2. Error correction term in vector auto regressive model

After applying Johansen-Juselius Co-integration test we are able to make error correction term which is as below:

LCPI = 0.0003*lex+0.0001*lwwp+0.006*lwop+0.0001*llbr

The likelihood ratio test confirms that all the regressors in this equation significantly Granger cause the price level. In addition to it, the labor supply and world wheat prices are endogenously determined while exchange rate and world oil price are exogenous to the system.

It also explains that if LCPI > 0.0001*Lex +0.0001*Lwwp+0.006*Lwop+0.0001*Llbr, than the price level falls and exchange rate, world wheat price, world oil price and supply of the labor to rise to restore the equilibrium. In the price level each month 58.83% of the discrepancy from the long run equilibrium is corrected.

4.4.1.3. Auto regressive distributed lags (ARDL)

As a first step we check the co-integration between variables by using the 'auto regressive distributed lag' (ARDL) model.

$$\Delta Lcpi_t = \gamma_0 + \sum_{i=1}^{n} \gamma_{1i} \Delta Lcpi_{t-i} + \sum_{i=1}^{n} \gamma_{2i} \Delta Lex_{t-i} + \sum_{i=1}^{n} \gamma_{3i} \Delta Lwwp_{t-i} + \sum_{i=1}^{n} \gamma_{4i} \Delta Lwop_{t-i} + \sum_{i=1}^{n} \gamma_{5i} \Delta Llbr_{t-i} + \alpha_1 Lcpi_{t-1} + \alpha_2 Lex_{t-1} + \alpha_3 Lwwp_{t-1} + \alpha_4 Lwop_{t-1} + \alpha_5 Llbr_{t-1} + \mu_t \quad (4)$$

From equation (2) we establish the following mode:

If $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ then it signifies that there is no co-integration among the variables.

Table 6. ARDL Co-integration testing

F TEST VALUE = 5.68	**P-value (0.0001)**	
CRITICAL VALUE	I(0)	I(I)
5%	2.86	4.01
10%	2.45	3.52
Critical values from table C1-iii of Pesaran *et al.* (2001)		

The Johansen-Juselius test confirms 2 co-integration vectors in our equation which also confirms by the ARDL test. It rejects the null hypothesis of 'no co-integration' between variables as the estimated F-value lies outside the upper bound of the critical values.

4.4.1.4. Granger causality in ARDL

After getting the confirmation of co-integration we proceed further and test the Granger causality in our model variables. The empirical results are as below:

Table 7. Granger Causality in ARDL (Likelihood Ratio Test)

Variable	∆Lcpi	∆Lex	∆Lwwp	∆Lwop	∆Llbr
Lags ∆Lcpi	1.289(0.287)	0.082(0.969)	0.071(0.974)	1.314(0.277)	0.499(0.684)
Lags ∆Lex	0.386(0.764)	2.106(0.108)	0.775(0.512)	2.003(0.122)	0.221(0.881)
Lags ∆Lwwp	2.894(0.042)	0.629(0.599)	2.566(0.062)	1.001(0.298)	1.051(0.374)
Lags ∆Lwop	0.292(0.831)	0.020(0.996)	0.731(0.537)	3.958(0.012)	0.589(0.624)
Lags ∆Llbr	2.911(0.042)	0.757(0.522)	0.274(0.843)	1.605(0.197)	0.021(0.995)
ECT_{t-1}	2.543(0.055)	0.582(0.661)	-0.013(0.937)	-0.216(0.141)	0.013(0.485)

Note: ( ) indicate p-values of F-statistics and p-values for student t-statistics in case of ECT.
Source: (Author's estimation).

4.4.1.5 Empirical results

To test the factors affecting the price level through the supply side cost push effects by using two econometric approaches i.e. Johansen-Juselius and Auto Regressive Distributed Lags (ARDL). The empirical results of this study are not reflected that in the long run all the right hand side variables Granger cause the price level. Nevertheless, in the short run world wheat price and labor supply Granger cause the price level significantly. This imply the fact that in the case of Tajikistan the world wheat price has gigantic influence because it secondarily affect the domestic wheat price which is a major candidate in the calculation of consumer price index. Secondly, the supply of labor has a huge role in the price level as the rural-urban migration disintegrates the equilibrium in the labor market. Theoretically speaking shortage of labor affects the factor price in the short run and possibly influence the general price level which is also confirms by the Granger causality test of this study.

4.4.2 Model for capturing the determinants of demand Pull inflation

4.4.2.1. Johansen-Juselius Co-integration

We have already established the order of integration between the variables used to capture the demand pull effects. We proceed further by using the equation-3 for the empirical analysis by following the same pattern we used to get the cost push inflation determinants.

We formulate a VAR and used the lag length as specified by the information criteria. All the information criterions i.e. 'likelihood ratio' (LR), 'final prediction error' (FPE), 'Akaike information criterion' (AIC), 'Hannan-Quinn' (HQ) and 'Schwarz information criterion' (SIC) suggest eight lags are appropriate for this VAR. Consequently, we choose eight lags on the basis of abovementioned criteria.

In addition to it we check the appropriation of lag length by using the lag exclusion test to and found all lags are significant so we could not exclude any lag in the VAR.

Table 8. Johansen Co-integration (Trace Test)

Hypothesized Co-integrating H_0	No. of Relationships H_1	Trace Statistic LR	5% Critical Value	1% Critical Value
r ≤ 1	r > 1	255.83*	82.18	90.83
r ≤ 2	r > 2	153.04*	58.57	65.73
r ≤ 3	r > 3	79.05*	39.04	45.37
r ≤ 4	r > 4	34.79*	23.37	28.80
r ≤ 5	r > 5	15.41	11.55	15.78

Source: (Author's estimation); Note: * indicates rejection of H_0 at 1% level. Likelihood ratio test (LR) confirms 4 co-integrating vectors

Table 9. Johansen Co-integration (Maximum Eigen Value Test)

Hypothesized Co-integrating H_0	No. of Relationships H_1	Max-Eigen Statistic	5% Critical Value	1% Critical Value
r ≤ 1	r > 1	102.79*	36.65	42.05
r ≤ 2	r > 2	73.99*	30.31	35.60
r ≤ 3	r > 3	44.25*	23.97	28.65
r ≤ 4	r > 4	19.37	18.04	22.41
r ≤ 5	r > 5	15.02	11.55	15.78

Source: (Author's estimation); **Note:** * indicates rejection of H_0 at 1% level. Max-Eigen Value test indicates 3 co-integrating vectors.

4.4.2.2. Granger causality in Johansen-Juselius model

We established our error correction term after normalization of variables to get the Granger causality in ECM-VAR in Johansen-Juselius model. The empirical results shown inconsistent pattern as in the short run we could not get any conclusive evidence of Granger causality in our demand pull inflation equation. We further check our results by using ARDL for demand pull effects.

4.4.2.3. Auto regressive distributed Lags (ARDL)

We iterate the same procedure which we used in our cost push model for the specification of auto regressive distributed lags (ARDL). Following the equation (3) for the testing of the Granger causality:

$$(3) ===> \Delta Lcpi_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta Lcpi_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta Lgdp_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta Lrmt_{t-i} + \sum_{i=1}^{n} \beta_{4i} \Delta Lrw_{t-i} + \sum_{i=1}^{n} \beta_{5i} \Delta Lbm_{t-i} + \sum_{i=1}^{n} \beta_{6i} \Delta Lgex_{t-i} + \phi_1 Lcpi_{t-1} + \phi_2 Lgdp_{t-1} + \phi_3 Lrmt_{t-1} + \phi_4 Lrw_{t-1} + +\phi_5 Lbm_{t-1} + \phi_6 Lgex_{t-1} + \varepsilon_t$$

If $\phi_1 = \phi_2 = \phi_3 = \phi_4 = \phi_5 = \phi_6 = 0$ then it signifies that there is no co-integration among the variables.

Table 10. ARDL Co-integration Testing

F TEST VALUE = 2.805	P-value (0.1174)	
CRITICAL VALUE	I(0)	I(I)
5%	2.62	3.79
10%	2.26	3.35
Critical values from table C1-iii Pesaran *et al.* (2001)		

F/Wald Test of zero restriction.
Source: (Author's estimation).

The empirical results could not establish the co-integration in ARDL as the estimated F-value lies in inconclusive region. Though, we proceed further and check our error correction model to get the idea about co-integration between the variables.

4.4.2.4 Granger Causality in ARDL

After getting the confirmation of co-integration we proceed further and test the Granger causality in our model variables. The empirical results are as below:

Table 11. Granger Causality in ARDL

Variable	∆Lcpi	∆Lgdp	∆Lrmt	∆Lbm	∆Lgex	∆Lrw
Lags ∆Lcpi	1.228(0.315)	1.061(0.411)	0.293(0.963)	0.746(0.650)	1.967(0.080)	1.920(0.080)
Lags ∆Lgdp	9.877(0.000)	7.436(0.000)	4.540(0.008)	0.543(0.656)	1.869(0.152)	3.784(0.018)
Lags ∆Lrmt	6.715(0.000)	2.141(0.072)	3.912(0.004)	0.596(0.703)	1.427(0.231)	0.583(0.743)
Lags ∆Lbm	6.697(0.003)	0.781(0.465)	0.390(0.679)	0.164(0.849)	0.249(0.780)	0.131(0.877)
Lags ∆Lgex	12.879(0.001)	1.755(0.193)	0.122(0.728)	0.483(0.491)	0.144(0.706)	0.0005(0.982)
Lags ∆Lrw	5.506(0.025)	0.135(0.714)	0.924(0.342)	0.016(0.899)	18.813(0.000)	0.356(0.554)
ECT_{t-1}	0.870(0.000)	-0.866(0.000)	-0.370(0.016)	0.011(0.781)	0.103(0.743)	-0.279(0.000)

Source: (Author's estimation).
Note: ( ) indicates p-values of F-statistics and p-values for student t-statistics in case of ECT Likelihood Ratio Test.

Conclusions

Over a few years inflation remains a big problem for the economy of Republic of Tajikistan so that this study investigates the prime factors affecting the price level by using the econometric techniques namely 'auto regressive distributed lags' (ARDL) and Johansen-Juselius co-integration within the VAR framework. We used the dataset which comprises the demand pull and cost push inflation indicators. We used monthly data for a period of 2005 to 2012 for Granger causality tests to know the exact impact of demand and supply side factors to the price level.

To test the factors affecting the price level through the supply side cost push, our empirical results suggest that in the long run exchange rate, world wheat prices, world oil prices and labor supply are endogenously determined in the system as their error correction terms are significant except broad money and government expenditures. Nevertheless, in the short run world wheat price and labor supply Granger cause the price level significantly. This implies the fact that in the case of Tajikistan the world wheat price has gigantic influence because it secondarily affect the domestic wheat price which is a major candidate in the calculation of consumer price index. Secondly, the supply of labor has a huge role in the price level as the rural-urban migration disintegrates the equilibrium in the labor market. The shortage of labor affect the factor prices in the short run and possibly influence the general price level which also confirms the Granger causality in their relationship.

For Demand side determinants of inflation, our results are quite consistent and suggest that in the long run, GDP gap, remittances inflow, and real wages are endogenously determined in the system as they significantly affect the price level. But in the short run, GDP gap, remittances inflow, broad money, government expenditure and real wages Granger causes the price level. Furthermore, there is a bi-directional Granger causality between GDP gap and remittances inflow. Also, real wage Granger causes the government expenditures implying more fiscal burden on government. The GDP gap Granger causes the real wage, implying the scenario that a major cause of under production is the low level of employment. Finally the price level also Granger causes the real wage, is a reflection of a negative relationship between them.

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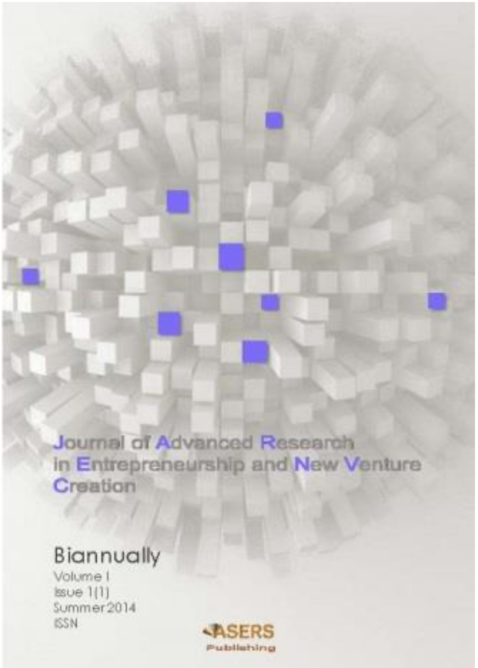

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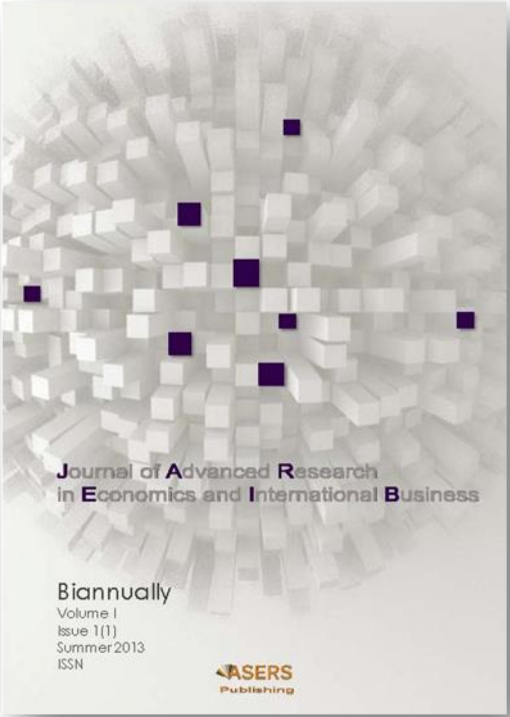

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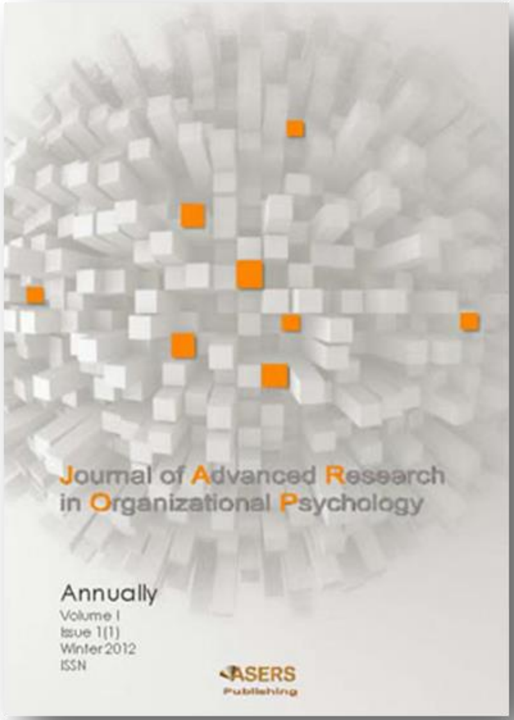

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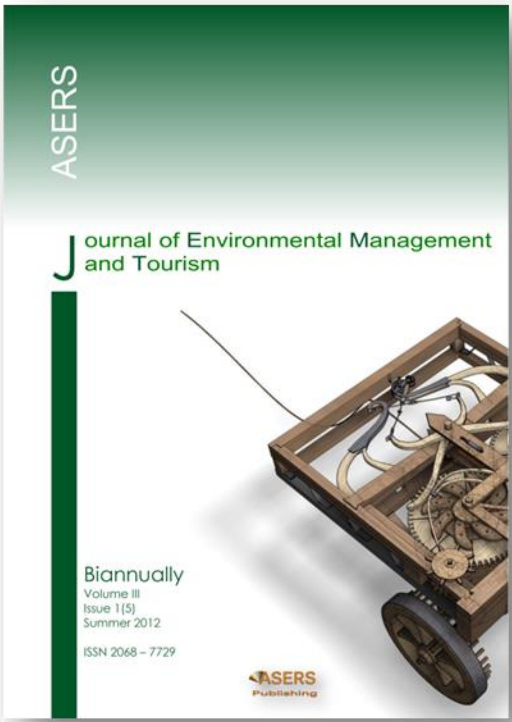

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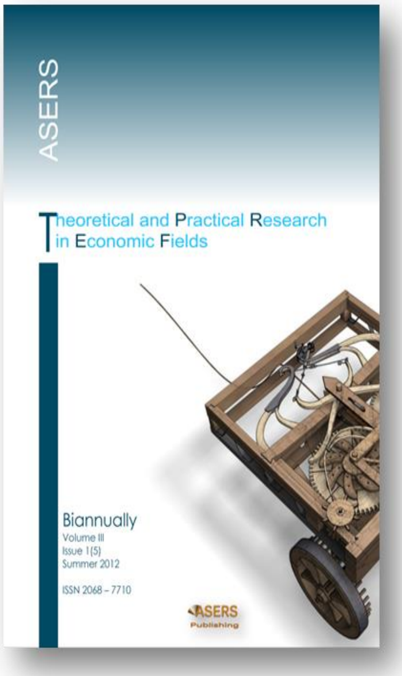

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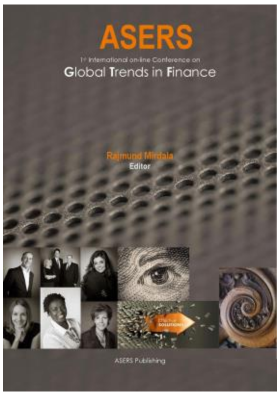

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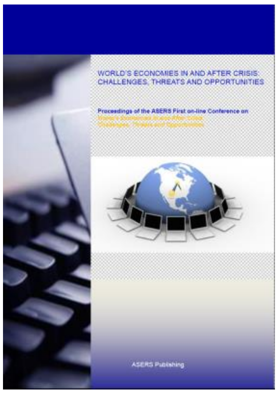

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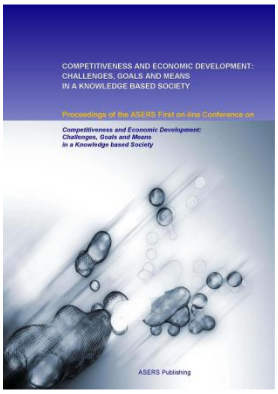

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