In°ation Risk and Portfolio Allocation in the Banking System

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ABSTRACT

This paper proposes theory and evidence on the relationship between in°ation and the bank's portfolio allocation. The proposed idea rationalized what Rodriguez (1992) pointed out with respect to the Central Bank of Argentina, behaving as a "borrower of ¯rst resort", where banks reallocated their investment from the private sector to government bonds.

A main component of in°ation costs is the misallocation of resources, this paper shows a channel through the reallocation of credits, where the credit market for the private sector trend to disappear.

Theoretically, this paper studies the behavior of risk-neutral ¯nanciers in a world in which monitoring costs, and limited liability on the part of ¯rms leads to credit rationing equilibria. In light of the well established relation between in°ation and changes in relative prices, the theoretical model rationalizes the relationship between in°ation and the allocation of capital in the banking system. Empirically, it looks at the dynamic behavior of the composition of bank's assets in Argentina between 1983 and 1998, which shows a robust relationship between relative price variability and bank's allocation in government denominated assets.

1 Introduction

The Latin-American experience revealed the destructive effect of the inflation on the economy.[1] There are two well-known inflation costs due to the costs of changing prices (Fender, 1990) : i) the cost of changing prices itself, and ii) the cost of a misallocation of resources due to the greater fluctuation in relative price. This paper shows a channel for the misallocation of resources generated by inflation, where the misallocation comes from reallocation of credit lines from private firms to the government.

Taking into account the well established positive correlation between inflation and relative price variability, the paper claims that an increase in relative price variability change the bank's incentive from making loans to private firms to invest in government bonds. The driving mechanism is that an increase in relative price variability increases the default probability of firms, which make banks reluctant to give loans to private firms generating a credit constraint equilibria. In other words, the market for private credit disappears. This resul is in the line of Casella and Feinstein (1990), where the authors showed that in at high inflation rates the volume of transaction fall.

This bank's asset reallocation was already pointed out by Rodriguez (1992). Rodriguez explained how the Central Bank of Argentina in the late 80's came to be the "borrower of first resort". In those times, according to Rodriguez, banks prefered to invest in government bonds instead of making loans to firms, because banks perceived trading with the government to be less risky than trading with the private sector. There are some fancy stories in the line of what Rodriguez called a borrower of first resort. For example, the Central Bank of Argentina once wanted to reduce the remunerated reserve requirements, but banks started to criticize this policy claiming that it would destroy the banking system.

A competitive theory for this episodes was presented by Calvo and Vegh (1995). The authors explained that sometimes government used the interest rate to fight inflation and defend the currency in many high inflation countries. For the special case of Argentina, they showed that, first, commercial banks borrowed from the public in time deposit, and second, banks deposited this money in the Central Bank. Then, an increase in the Central Bank interest rate creates incentive to the public to invest in time deposit, and banks reinvest the money in the Central bank.

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[1] An interesting fact about inflation is that there is a huge literature discussing not only the cost of inflation itself, but also the cost when the government try to get ride of it. Calvo and Vegh (1998) present a comprehensive summary of the second issue, the cost of government policies to eliminate inflation. In their summary, inflation is classified in two types: hyperinflation and chronic inflation. Among the difference between these two types of inflation, the empirical literature found that is cheaper to eliminate the inflation from an hyperinflation process than from a chronic inflation process. Examples of reducing inflation from an hyperinflation case can be Germany in the 20', Bolivia in the 80', Argentina in the 90'. In these countries the inflation rate fall overnight at no output cost. On the other hand, the empirical literature shows that reducing inflation from a chronic situation generates an output cost, where this cost is independent to the stabilization plan used (exchange rate or money base).

°ation and the allocation of bank's assets. Empirically, taking into account stylized fact of the positive correlation between in°ation and relative price variability, the paper looks at the dynamic behavior of the composition of bank's assets in Argentina between 1983-1998, and it ¯nds a robust relationship between relative price variability and the fraction of bank's portfolio invested in government denominated assets. The e®ects of the relative price variability on bank's portfolio allocation is presented in the data even when we control for the level of economic activity and for the size of the budget de¯cit.

Formally, this paper argues that in markets with asymmetric information and limited liability on the parts of borrowers, changes in relative price dispersion are likely to a®ect bank's pro¯tability and the allocation of bank's asset, in a way consistent with credit rationing equilibria in markets with imperfect information(Stiglitz and Weiss, 1981). In this context, the paper studies the behavior of risk-neutral ¯nanciers in a world in which bankruptcy risk and adverse selection on the part of borrowers produce a non monotonic relationship between the ¯nancier's expected pro¯t and the interest rate. The logic of the argument is the following: when ¯rm's failure is costly to the lender (e.g. cost of a bankruptcy), an increase in the loan rate of interest may decrease the net return to the bank, since it increases the probability of failure of the borrower[2].

In this environment, the allocation of bank's portfolio between the risky asset and the alternative risk free asset depends not only on the di®erence between the expected return of the two assets, but also on the variance of the risky asset's return[3]. We show that when ¯nanciers are heterogeneous with respect to the monitoring costs, in the spirit of Williamson (1987), an increase in the variance of a mean preserving distribution of returns induces a portfolio reallocation towards the risk free asset. In addition, the real interest rate charged to risky borrowers rises, in a way consistent with the time series evidence on lending rate in Argentina. This paper argues that this mechanism, albeit neglected by the previous literature on in°ation, can rationalize the relation between in°ation and bank lending in Argentina, and is a potentially important (and costly) element of the real e®ect of in°ation.

The paper proceeds as follows. Section 2.2 looks at the bank's portfolio allocation in Argentina, and the behavior of the interest rate from 1983 to 1998. Section 2.3 shows the existing evidence on the relation between in°ation and relative prices, with particular reference to Argentina. Section 2.4 presents the theoretical model describing the relation between lender and borrowers. Section 2.5 concludes.

[2] See Williamson, 1987 for the microeconomic description of the mechanism we focus on. The macroeconomic implication of a non monotonic relationship between bank's pro¯t and the lending rate have been discussed by Mankiw (1986) and by Bernanke and Gertler (1990)

[3] The variance is represented by the price level variability

2 In°ation and Bank Lending in Argentina

The theoretical model, presented section 2.4, shows that the relation between in°ation and bank's asset allocation is based on the e®ect of the relative price variability on the bank's asset allocation. This section provides some empirical evidence on the relationship between bank's asset allocation and relative price variability in Argentina for the period between 1983 and 1998.

This section shows the graphic relation between in°ation and bank's asset allocation. The main idea behind this graph is that an increase in relative price variability increases the default probability of ¯rms, which make banks reluctant to give loans to private ¯rms. So, given by the well established positive correlation between in°ation and relative price variability, an increase in in°ation will incentive banks to constrain credit from ¯rms. As result, the market for private credit disappears. This situation was already pointed out by Rodriguez (1992). Rodriguez explained how the Central Bank of Argentina in the late 80' becomes to be the "borrower of ¯rst resort". In those time, according to Rodriguez, banks prefer to invest in government bonds instead of making loans to ¯rms because banks noted less risk trading with the government than trading with the private sector.

A competitive theory for this episodes was presented by Calvo and Vegh (1995). The authors explained that sometimes government used the interest rate to ¯ght in°ation and defend the currency in many high in°ation countries. For the special case of Argentina, they showed that, ¯rst, commercial banks borrowed from the public in time deposit, and second, banks deposited this money in the Central Bank. Then, an increase in the Central Bank interest rate creates incentive to the public to invest in time deposit, and banks reinvest the money in the Central bank.

We explicitly consider Argentina because of its large swing in in°ation over the last 15 years. For several decades, Argentina had been classi¯ed as a chronic in°ation country, and in the late 80's experienced also hyperin°ation, with quarterly in°ation reaching 334 percent in the ¯rst quarter of 1990. However, since 1991, Argentina recorded an unprecedented change in the economic policies. With the introduction of the Convertibility Plan, dated in March 1991, in°ation rate rapidly drop below 10 percent and stabilized below 1 percent per quarter since 1995. These large swings is observed in both, in°ation and relative price variability plotted in graph 2.1.

The propose of this section is to analyze the e®ects of the relative price variability on the asset allocation in the banking system. For this purpose we de¯ne K_t^{bs} as the proportion of bank assets invested in government denominated assets. More formally, if $priv_t$ are the banking sector claims on the private sector at time t, pub_t are the claims on central government, and K_t^{bs} is de¯ned as the percentage of claims on the public sector, then K_t^{bs} would be,

$$K_t^{bs} = \frac{pub_t}{pub_t + priv_t} \tag{1}$$

We used the data from the International Financial Statistics. With reference to equation 2.1, we distinguish between two di®erent levels of aggregation.

More speci¯cally, pub_t refers to claims on central government (rows 52an and 22an), while $priv_t$ refers to claims on private sector (rows 52d and 22d)[4]. In addition, we will also use the real GDP and the government quarterly ¯nancing needs (row 84a).

Figure 2.2 plots the series K_t^{bs} between 1983 and 1998. This graph shows that the bank's asset allocation experiences a large swing over the entire sample, raising during the pre-convertibility period and falling during the 90's. Table 2.1 reports a summary statistic for the aggregate variables of our analysis. Quarterly in°ation averaged 42 percent over the full sample, with remarkable di®erences between the pre-convertibility plan period, where it averaged more than 75 percent, and the latter part of the sample, where quarterly in°ation fell to 3 percent per quarter. Over the same sub-sample period, K_t^{bs} followed a similar pattern, with an overall average equal to 28 percent.

In addition, table 2.1 reports also simple correlations, and shows that the contemporaneous correlation between relative price variability (RPV) and K_t^{bs} is 0.54 for the entire sample, raising to 0.82 in the 90s, suggesting that the correlation is also present in the low in°ation period.

Table 2.1: Summary Statistics

Variable	Mean
Full Sample: 1983.q1-1998.q1	
k^{bs}	27.6
In°ation (¼)	42.37
De¯cit (d)	-.03
GDP Growth (g)	2.99
$Corr(k^{bs}; RPV)$	.54
$Corr(k^{bs}; d)$	.30
$Corr(k^{bs}; g)$	-.21
High In°ation Period: 1983.q1-1991.q1	
k^{bs}	.30
In°ation (¼)	76.3
$Corr(k^{bs}; RPV)$	0.53
Low In°ation Period: 1991.q1-1998.q1	
k^{bs}	25.8
In°ation (¼)	3.6
$Corr(k^{bs}; RPV)$	0.82

Source: International Financial Statistics and INDEC (Instituto Nacional de Estadisticas y Censos-Argentina)

To gain intuition, each of the ¯gure 2.3 and 2.4 plots a scatter diagram of K_t^{bs} and the log of in°ation[5]. The di®erence between these two graphs is that ¯gure 2.3 included the whole sample, while graph 2.4 only the information where

[4] Throughout the analysis K_t^{bs} refers to row 22

[5] Since quarterly in°ation in the 90s has negative values, we make a monotonic transformation of in°ation, $¼_t = \ln(1 + \tilde{¼}_t)$, where $\tilde{¼}_t$ is the observed in°ation at time t.

log of inflation is less than 0.2. The goal of this split is to show the relation between these variables clearly. In both graphs we observe that an increase in the inflation rate relates to an increase in the proportion of free risk assets invested by banks.

Figure 2.5 plots relative price variability and K_t^{bs}, which is the relation we want to test. Despite the fact these graphs show a clear relation between the variables, next section would try to understand whether the positive relationship observed in the raw data is spurious, or if this relation results from the bank's profit maximization process.

2.0.1 Methodology

The empirical analysis involves regressing K_t^{bs} on relative price variability, controlling for output growth and the government budget deficit. Formally we estimate,

$$K_t^{bs} = a + \sum_{i=1}^{M} \alpha_i k_{t-i}^{bs} + \sum_{i=0}^{N} \beta_i RPV_{t-i} + \sum_{i=0}^{Q} \delta_i g_{t-i} + \sum_{i=0}^{Q} \sigma_i d_{t-i} + \sum_{i=0}^{R} \eta_i x_{t-i} + \varepsilon_t \quad (2)$$

where K_t^{bs} is the ratio given by equation 2.1, RPV_t is the relative price variability, g_i is the output growth rate, d_t is the government budget deficit as percentage of the GDP and x is a set of regressors that control for possible non linearities and structural breaks in the time series. Data range from first quarter of 1983 to the first quarter of 1998.

The regression in equation 2.2 has two potential problems. The first one concerns the choice of the appropriate lag structure, and the second one has to do with the degree of integration of the selected time series. While the first problem is addressed by applying the Akaike and Schwarz criteria to optimally select M,N,Q and R, the non-stationarity of the regressors is potentially more serious. The risk is that the relationship plotted in figure 2.5 could be spurious and that the two variables will not be cointegrated. Ex-ante, however, we would not expect the ratio K_t^{bs} to be a non stationary variable. In addition, K_t^{bs} is bounded between 0 and 1 by construction. Nevertheless, it may be the case that in the relative short period of investigation, the stochastic process describing K_t^{bs} be statistically indistinguishable from a non-stationary process. For this purpose, we apply the two-stage procedure proposed by Pesaran, Shin and Smith(1996). The procedure consists in using the error correction specification of equation 2.2, and performs a variable deletion test on the coefficients on the lagged levels of K_t^{bs}, RPV_t, g_t, and, d_t. The null hypothesis is the non-existence of a long run relationship, in other words, the instability of the model.

This procedure allows us to avoid the pre-testing problems associated with the standard cointegrating analysis, which requires the unequivocal classification of variables into I(0) and I(1). More specifically, we re-write equation 2.2 in the error correction form

$$\Delta K_t^{bs} = c + \theta k_{t-1}^{bs} + \rho RPV_{t-1} + \sigma g_{t-1} + \phi d_{t-1} + \psi x_{t-1} + \sum_{i=1}^{M} \alpha_i \Delta k_{t-1}^{bs} + \sum_{i=1}^{N} \beta_i \Delta RPV_{t-1} + \tag{3}$$

$$+ \sum_{i=1}^{Q} \delta_i \Delta g_{t-1} + \sum_{i=1}^{M} \varphi_i \Delta d_{t-1}^{bs} + \sum_{i=1}^{R} \eta_i \Delta x_{t-1} + w_t$$

and we perform an F test on the lagged level values of K_{t-1}^{bs}, RPV_{t-1}, g_{t-1}, and, d_{t-1}. The test is the non-existence of a long run relationship.

2.1 Results

Tables 2.2 and 2.3 report the results of our regressions. For the purpose of our analysis, the most important result in these tables is given by the stability test of table 2.3, which test the null hypothesis of a long run relationship.

In table 2.2, we report two different specifications for equation 2.2. The first specification, is the basic regression of equation 2.2 without any additional regressor x. The second specification includes a dummy CB that takes the value of 1 for the period following the Convertibility law (March 91). Table 2.2 shows that both RPV_t and d_t are important determinants of the allocation of capital in the banking system, while the role of the output growth does not appear to be significant. In addition, controlling for the implementation of the convertibility law seems to be not important.

Table 2.2: Bank's Capital Allocation
Dependent Variable: Share of Bank Portfolio
Invested in Government Denominated Assets
Quarterly Data: 1983.q1-1998.q1

		Basic	Structure	CB Dummy	
Regressor	Parameter	Coefficient	t-ratio	Coefficient	t-ratio
k_{t-1}^{bs}	α	0.78***	12.68	0.78***	12.43
RPV_t	β_1	0.64***	2.77	.67**	2.02
g_t	δ	-0.01*	-1.82	–.01*	–1.80
d_t	σ_1	0.27***	2.84	0.27***	2.62
Const.	a	0.05***	3.60	.05***	2.91
CB				.01	.10

Note: One, two and three asterisks indicate significance at the 10, 5 and 1 percent respectively.

Table 2.3 reports the coefficients of the long run relationship between K_t^{bs} and the other aggregate variables. This table shows that relative price variability is the only variable that is persistently significant at a significance level of 5%.

The specification "High Inflation " is a dummy variable where it takes one in case that the inflation rate is higher than 40% quarterly.

However, when the controlling variable for the stabilization plan is included, none of the variables seem to be significant.

Then, Table 2.3 shows that in the basic structure the effect relative price variability is significant and the effect of the other two regressors (d and g) are not significant.

Table 2.3: Long Run Coefficients

Dependent Variable: k_t^{bs}

Specification	RPV	g	d	CB	π^h	Stability Test
Basic Structure	0.89**	-0.01	0.35*	-	-	6.61***
CB Dummy	0.93	–.01	0.034	0.01	-	5.41**
High Inflation	1.17***	–.01	0.33	-	–.01	6.72***

Note: One, two and three asterisks indicate significance at the 10, 5 and 1 percent respectively.

As we will show in section 4, our theoretical perspective has clear implication on the behavior of the lending rate over different level of inflation. The problem with lending rates in Argentina is the fact that the reported series refer to the official lending rates, which was controlled and set by the government. The only interest rate that appears to be market determined is the interbank rate, the lending rate charged by for short term interbank lending. Even though we do not try to explain the dynamics of the real rates, figure 2.6 reports this serie[6].

Two things appear clear from figure 2.6. First, real interest rates are much higher in the pre-convertibility law period. And second, the volatility of the real interest rate is also higher during the pre-convertibility period.

3 Relative Price Variability and Inflation

This paper argues that the relation between inflation and the bank's portfolio allocation, established in the previous section is linked to the relationship between inflation and relative prices. This section reviews the literature on relative price variability and inflation, while in the theoretical section, we will show the relation between relative price variability and bank's asset allocation.

The relation between the movement of individual relative price with respect to the aggregate price level has been investigated at least since Mill's (1927) description of the US price system. Most of the papers suggest that inflation and relative price changes are strongly positively correlated. Let's define RPV as the deviation of the rates of inflation of different goods and services around the average consumer price inflation. Parks(1978), Fischer (1981) and several others authors have shown that his measure of price variability, defined as intermarket price variability, and the aggregate inflation rate are positively correlated over time. Similar results was by Glejser (1965) for a cross-section of European countries.

[6] Figure 3 does not plot the value of the interest rate between 1989-1991, which is the hyperinflation period.

Some works have attempted to determine whether this relationship is stronger between inflation and RPV using both, the anticipated and the unanticipated change in inflation. Parks (1978) argued that the relationship was driven by changes in unanticipated inflation rather than the level of inflation. however, Fischer (1981) regressed RPV on inflation, changes in inflation (expected and unexpected inflation). He found that both, expected and unexpected inflation, had a positive and significant relationship with RPV. More recently, Debelle and Lamont (1997) test whether the time-series positive correlation of inflation and intermarket relative price variability is also present in a cross section of US cities. They showed that cities that have higher than average inflation also have higher than average relative price dispersion.

Another set of papers look at the empirical relationship between intramarket price variability, this is the variability of relative prices of a given product across stores, and the expected and unexpected component of inflation. Empirically, it appears that different sellers vary in the timing and size of nominal price changes. Consequently, there is variability in the price level across identical products at a point in time, and a number of authors have found a positive relationship between intramarket price variability and inflation. Van Hoomissen (1988), Lach and Tsiddon (1992) and Tommasi (1994) used data on the same product across different stores in countries that were experiencing a high inflation rate (Israel 1971-1984 and Argentina 1990, respectively). In addition, Tommasi (1994) showed that even though an increase in inflation leads to higher variability, at very high rates of inflation the relationship is reversed, and an increase in inflation reduces the relative price variance[7].

4 Model of Bank Lending and Inflation

Most of the recent theoretical literature on bank lending, following the seminal contribution of Stiglitz and Weiss (1981), has studied the effect of asymmetric information in the lender-borrower relation. A standard result in this literature predicts that, due to the moral hazard on the part of borrowers and adverse selection among different borrowers, the bank's expected return on a risky loan is a non monotonic function of the interest rate. In other words, a credit rationing equilibrium could arise because banks refute to supply loan at the prevailing interest rate to some of the existing customers. One of the easiest way to capture this mechanism, without explicitly modeling moral hazard or adverse selection problems, is to assume that entrepreneurs and borrowers are asymmetrically informed on the state of market and monitoring the output of firms has a cost. In this setting, Williamson (1987) had shown that a standard debt contract is the optimal arrangement. With respect to the mentioned assumptions, Williamson associated the monitoring cost as the bankruptcy costs. In addition, according with the author, asymmetric information means that only the debtor knows the true output of the project. Following the same idea, we propose a model

[7] A possible explanation for this event is that at high inflation rate all prices are quoted in foreign exchange rate.

in which heterogenous (with respect to the monitoring cost) and risk-neutral financiers decide whether to invest their fixed endowment between two alternative assets: a risk-free asset and a lending contract with ex-ante homogeneous entrepreneurs. Entrepreneurs and financiers are matched pairwise at the beginning of the period and in case of disagreement the entrepreneur has no possibility to change financier. In other words, financiers have monopolistic power vis-a-vis their client, and there is no free entry in the lending market.

Then, if borrowers decide to default, the lender will receive the output of the project after paying the bankruptcy cost. In the other state, borrowers do not default, the lender receive the contracted interest rate. Assuming mean preserving spread distribution for returns of the project, we will study the effect of an increase in the spread of the return distribution on the bank's portfolio allocation between these two assets.

4.1 Description of the Model

A borrower or entrepreneur would receive from his or her investment project a random return of $\tilde{p}_i$. In addition, we assume that the returns for each entrepreneurs are independent and identically distributes according to the probability density function $f(.)$ and the probability distribution $F(.)$. For analytical simplicity, we assume that f is uniformly distributed over the interval $(\mu - b; \mu + b)$, so that μ is the expected return of each project, where this distribution function is common knowledge. In this setting, the actions of the entrepreneurs do not affect the returns on investment projects, then, moral hazard is not a problem.

The realization of $\tilde{p}_i$, denoted by p_i is costless observed only by entrepreneurs, while the lender, or financier, can learn about the state of a particular p_i only by paying a idiosyncratic monitoring cost of γ_i(ea. bankruptcy cost). Financiers are heterogenous with respect to the cost γ_i, and a distribution function $H(\gamma_i)$, defined over the support [0,2b] describes the proportion of lender with idiosyncratic monitoring cost less or equal than γ_i. Thus, a contract between an entrepreneur and a financier will be a function $\pi(r^*(\gamma_i); \gamma_i)$, that specifies the payment transfer from the entrepreneur to the financier. In this type of setting, using the result established by Williamson (1987), the optimal contract is a standard debt contract, which specifies that the entrepreneur shall pay the lender a fixed amount r^* at the end of the period, unless the entrepreneur decides to default on his debt. In that case, the financier will receive the entire return of the project after paying the monitoring cost of γ_i. As a result, the expected profit for a financier with idiosyncratic monitoring cost of γ_i would be

$$\pi(r^*(\gamma_i); \gamma_i) = \int_{\mu - b}^{r^*} p f(p) dp + r^* [1 - \int_{\mu - b}^{r^*} f(p) dp] - \gamma_i \int_{\mu - b}^{r^*} f(p) dp \qquad (4)$$

where $r^*(\gamma_i)$ is the interest rate, determined by the maximization condition

$$r^*(\gamma_i) = \arg\max_r \rho(r^*(\gamma_i); \gamma_i) \tag{5}$$

In equation (2.4), the first expression represents the expected value of the project conditional on an entrepreneur decision to default, the second term is the revenue from the repayment r^*, weighted by the probability of repayment, while the last term is the expected cost of monitoring. Since the entrepreneur is the residual claimant of the project, and enjoys limited liability, its expected profit reads

$$\pi_i(r^*) = \int_{r^*}^{\mu+b} p f(p)dp - r^*[1 - \int_{\mu-b}^{r^*} f(p)dp] \tag{6}$$

The first expression of the above equation refers to the expected revenues from the project, while the second term is the interest rate cost, weighted by the surviving probability. While the formal derivation of the equilibrium will be derived in the next section, from equation (2.4), it would be helpful to show that the expected profit decrease with the idiosyncratic cost, or that

$$\frac{d\rho(.)}{d\gamma} = -\int_{\mu-b}^{r^*} f(p)dp \tag{7}$$

Regarding the other investment opportunity, financiers have access to a free risk investment which yields an expected return equal to i, with $i \,\mu\, \mu$. By virtue of the monotonicity of $\rho(.)$ with respect to r, the portfolio allocation between the two assets satisfies the reservation property. This reservation property could be described in terms of a reservation cost γ_d, such that lender with idiosyncratic effort larger than γ_d invests her portfolio only in the free risk asset. Using equation (2.5), the reservation effort is defined as

$$\rho(r^*(\gamma_d); \gamma_d) = i \tag{8}$$

Finally, if $H(\gamma_d)$ is the proportion of lender who decide to finance the entrepreneur, the portfolio allocation in the free risk asset , k^{bs}; would be

$$k^{bs} = 1 - H(\gamma_d) \tag{9}$$

In the next section we derive the equilibrium interest rate and we show that an increase in the spread of a mean preserving distribution of returns leads to a decrease in the banking expected profits, $\rho(\gamma_d)$ and an increase in the equilibrium interest rate r^*. This in turn, increases the reservation γ_d and increases the proportion of financiers who decide to invest their portfolio in the free risk asset.

4.2 The Lending Problem

We solve the problem in two steps. First, we determine the optimal interest rate for a given entrepreneur γ_i, μ and b. Next, we focus on the portfolio allocation to derive an analytical expression for the marginal financier γ_d. And finally, we derive the main comparative static property of the model.

In our simple set up, each idiosyncratic financier γ_i choose the interest rate r^* to maximize equation 2.4. Then, differentiating equation 2.4 with respect to r, yields

$$\frac{\partial \pi(.)}{\partial r} = 1 - \int_{\mu - b}^{r^*} f(p)dp - \gamma * f(p) = 0 \qquad (10)$$

Plugging in the above equation the assumed uniform distribution for the return, equation 2.10 could be rewritten as

$$1 - \frac{r^* - \mu + b}{2b} = \frac{\gamma_i}{2b} \qquad (11)$$

for $b \neq 0$, the equilibrium interest rate charged by financiers would be

$$r^* = \mu + b - \gamma \qquad (12)$$

Equation 2.12 shows that there is a unique maximum $r^*(\gamma_i)$; and that a positive interest rate requires $\gamma_i < 2b$. From equation 2.12, it immediately follows that an increase in the variance of returns, which is an increase in b in the terminology of this paper, is translated into a higher interest rate, $\frac{\partial r(.)}{\partial b} = 1 > 0$.

In addition, plugging the assumed uniform distribution in equation 2.4, the profit function turn out to be

$$\pi = \frac{r^2 - (\mu - b)^2}{4b} + r - r\frac{(r - \mu + b)}{2b} - \gamma\frac{(r - \mu + b)}{2b} \qquad (13)$$

Figure 2.7 shows the relation between π and r given by equation 2.13. This figure shows, for a given variance in returns b and cost of bankruptcy γ, a parabolic relation between the financier expected profit and the interest rate. In addition, this figure shows that the maximum interest rate is an increasing function of b,and that the maximum expected profit falls with the increase of b. This result is formally established in the following way.

Plugging equation 2.12, which is the optimal interest rate $r^* = \mu + b - \gamma_i$, in equation 2.13, and then, taking the derivative with respect to b, and rearranging terms,

$$\frac{\partial \pi}{\partial b} = -\frac{\gamma_i^2}{4b^2} < 0 \qquad (14)$$

This shows financier's expected profit is a decreasing function with respect to the variance of returns.

So far, we derived the optimal interest rate and the effect of an increase in the variance of the return in the expected profit. We are now in a position to derive a formal expression for the marginal financier γ_d.

The cut-off value γ_d would be determined by the following condition

$$\gamma_d \frac{(r^* - \mu + b)}{2b} = \frac{1}{2b} \int_{\mu - b}^{r^*} p f(p) dp + r^* \left[1 - \frac{(r^* - \mu + b)}{2b}\right] - i \qquad (15)$$

which states that for the marginal financier, the expected monitoring cost are equal to the difference between the expected gross return from lending to an entrepreneur and the return form the free risk asset.

Plugging the equilibrium condition $r^* = \mu + b - \gamma_d$ in equation 2.15, re-arranging, the equilibrium cut-off γ_d is the solution of the following quadratic equation

$$\gamma^2 - 4b\gamma + 4b(\mu - i) \qquad (16)$$

Equation 2.16 is a key equation of the model. This equation determines the reservation cost γ_d, whose expression would be[8]

$$\gamma_d = 2b - \sqrt{4b^2 - 4b(\mu - i)} \qquad (17)$$

Equation 2.17 explains that the decision to invest in the lending market depends on both, the difference between the two average returns $(\mu - i)$ and the variance of returns (b).

From equation 2.17 is clear that

$$\mu = i \Rightarrow \gamma_d = 0$$

In other words, an arbitrarily small monitoring cost γ_d is sufficient to invest the bank's portfolio in the free risk asset when there are no difference in the average return of these two assets.

Figure 2.8 plots the marginal cut-off (γ_d) values versus $\mu - i$ for different values of the inflation risk, b. Two points surge from this figure. First, higher average differential $\mu - i$ means that more financiers would be willing to concede loans to entrepreneurs at given b. Second, higher inflation risk (increase in b) decreases the amount of financiers willing to concede credits to entrepreneur. The later result could be established formally by differentiating equation 2.16 to yield

[8] The positive root is ruled out by the condition that $\gamma < 2b$.

$$\frac{\partial \gamma_d}{\partial b}(\gamma_d - 2b) = 2(\gamma_d - \mu + i) \tag{18}$$

Equation 2.18 implies that since $\gamma_d < 2b$, $\frac{\partial \gamma_d}{\partial b} < 0$ if and only if, $(\gamma_d - \mu + i) > 0$:

Therefore, this implies that as long as inflation increases the variance of relative returns without affecting the expected return on the risky asset (our assumption of mean preserving distribution), an increase in the variance would shift financiers portfolio allocation towards the free risk asset.

Formally, this result could be obtained by plugging 2.18 in the partial derivative of 2.1 with respect to b,

$$\frac{\partial k^{bs}}{\partial b} = -h\frac{\partial \gamma_d}{\partial b} > 0 \tag{19}$$

4.3 Discussion

This paper shows both, a theoretical and an empirical link between inflation and bank's portfolio allocation. These results rationalized what Rodriguez (1992) pointed out with respect to the Central Bank of Argentina, behaving as a "borrower of first resort". This expression refers to the reallocation of bank's credit from the private sector to the government.

The effect of inflation will be in the variance of return of the risky assets, where the increase in inflation increases the variance of returns. This assumed relation in our model between inflation and variance of returns is well established in the literature (i.e. Parks(1978), and Fischer (1981) among others). In this context, the model shows that limited liability on the part of borrowers, together with asymmetric information and costly monitoring in the borrower-lender contracts, induces a clear relation between inflation risk and bank's portfolio allocation, where an increase in inflation risk creates the incentive for banks to invest in free risk assets. Therefore, banks constrain the credit lines to firms, and as a result the market for private credit disappears.

A competitive theory for this episodes was presented by Calvo and Vegh (1995). The authors explained that sometimes government used the interest rate to fight inflation and defend the currency in many high inflation countries. For the special case of Argentina, they showed that, first, commercial banks borrowed from the public in time deposit, and second, banks deposited this money in the Central Bank. Then, an increase in the Central Bank interest rate creates incentive to the public to invest in time deposit, and banks reinvest the money in the Central bank.

The main implication of the model is that an increase in inflation creates an incentive for banks to do a portfolio reallocation towards free risk assets. Risk neutral financiers make their investment decision looking not only at the expected spread between the risky and risk free assets ($\mu - i$; in the terminology of this paper) but also looking at the variance of the risky asset return, b.

As policy implication, the government should reduce in°ation to eliminate the misallocation of resources mentioned above. On the other hand, the elimination of in°ation is not free for the economy. Calvo and Vegh (1998) made a comprehensive summary of these costs. So, there is a trade-o® in reducing the in°ation rate between the gain from a correct allocation of resources and a cost from the stabilization plan. Let us emphasize that this paper discusses a channel causing the misallocation of resources and not the project evaluation concerning the reduction of the in°ation rate, which is another issue and another paper.

In addition, given that the results obtained are originated in the assumptions of asymmetric information of the returns and monitoring cost for the ¯nanciers, another policy implication, if in°ation remains, is that government should implement policies to reduce these two problems, for example, a better bankruptcy law.

5 Conclusion

This paper shows a channel where in°ation a®ects the resource allocation in the economy. This channel is originated in the ¯nancier-entrepreneur relation where risk-neutral ¯nanciers decide to cut the credit line to the entrepreneur when the probability of default increases. The increase of the default probability comes form the fact that an increase in in°ation raises the variability of the asset's returns.

Empirically, we looked at relation between the dynamic behavior of the composition of bank's asset in Argentina between 1983 and 1998 and the relative price variability, and, we ¯nd a robust relation between the bank's asset allocation and the relative price variability.

The model predicts that an increase of the asset return variability would: i) Decrease the bank's pro¯t, ii) Increase the real interest rate, iii) Increase bank's portfolio of free risk assets.

As policy implication, the ¯rst best to eliminate the cost of the misallocation of resources is that the government should get ride of the in°ation. On the other hand, if in°ation remains, the government should implement policies to reduce the asymmetric information and the monitoring cost, for example improving the bankruptcy law.

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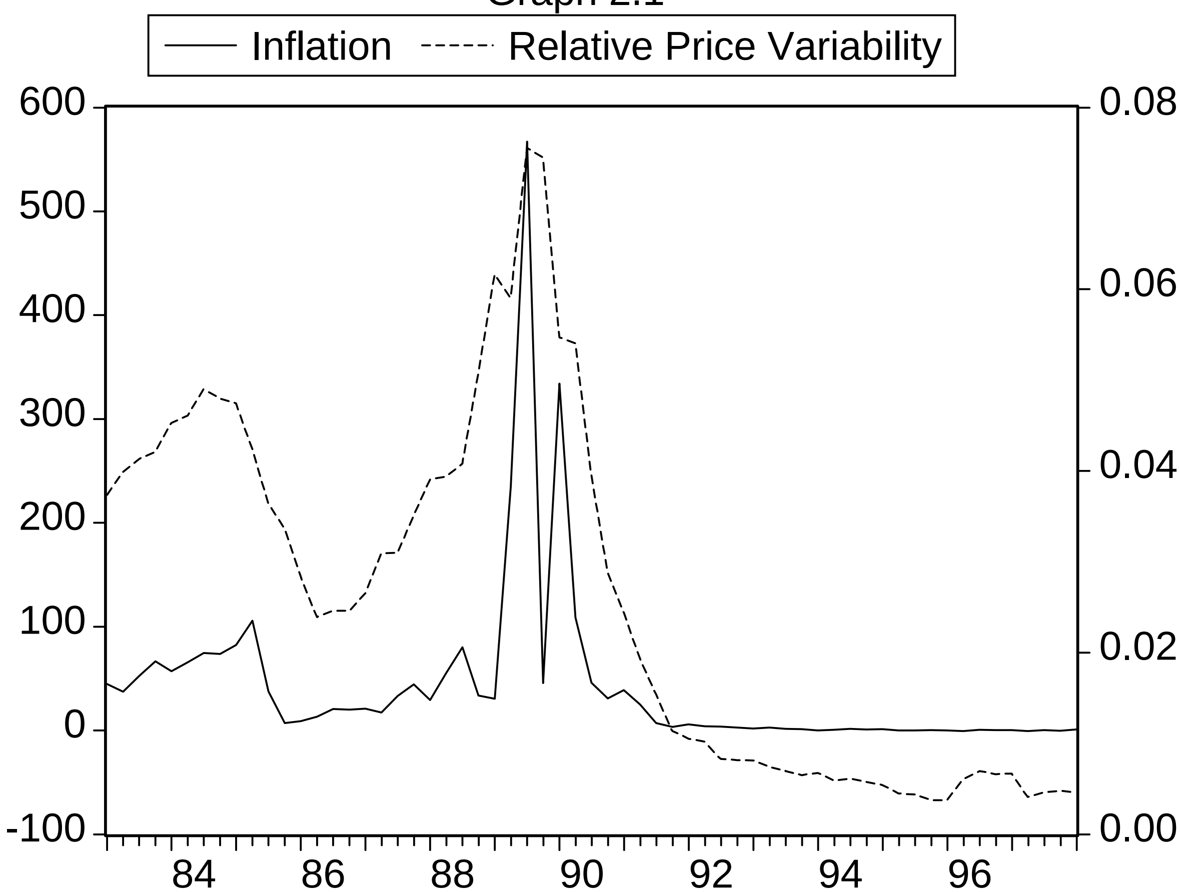
Graph 2.1



Inflation
Relative Price Variability
600
500
400
300
200
100
0
-100
0.08
0.06
0.04
0.02
0.00
84
86
88
90
92
94
96

Graph 2.2
Bank's Asset Allocation

Figure 2.3
Bank's portfolio allocation and Inflation

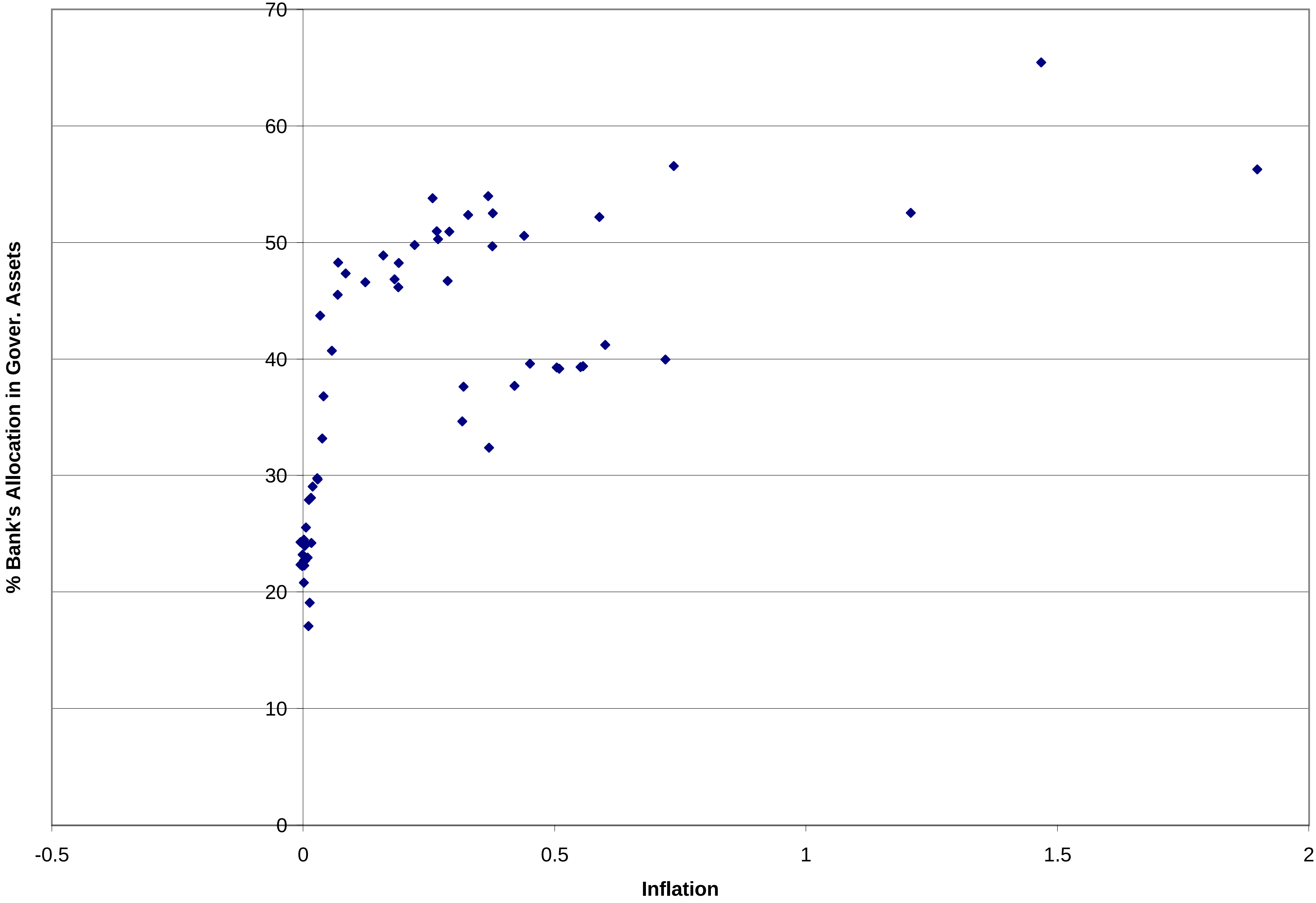
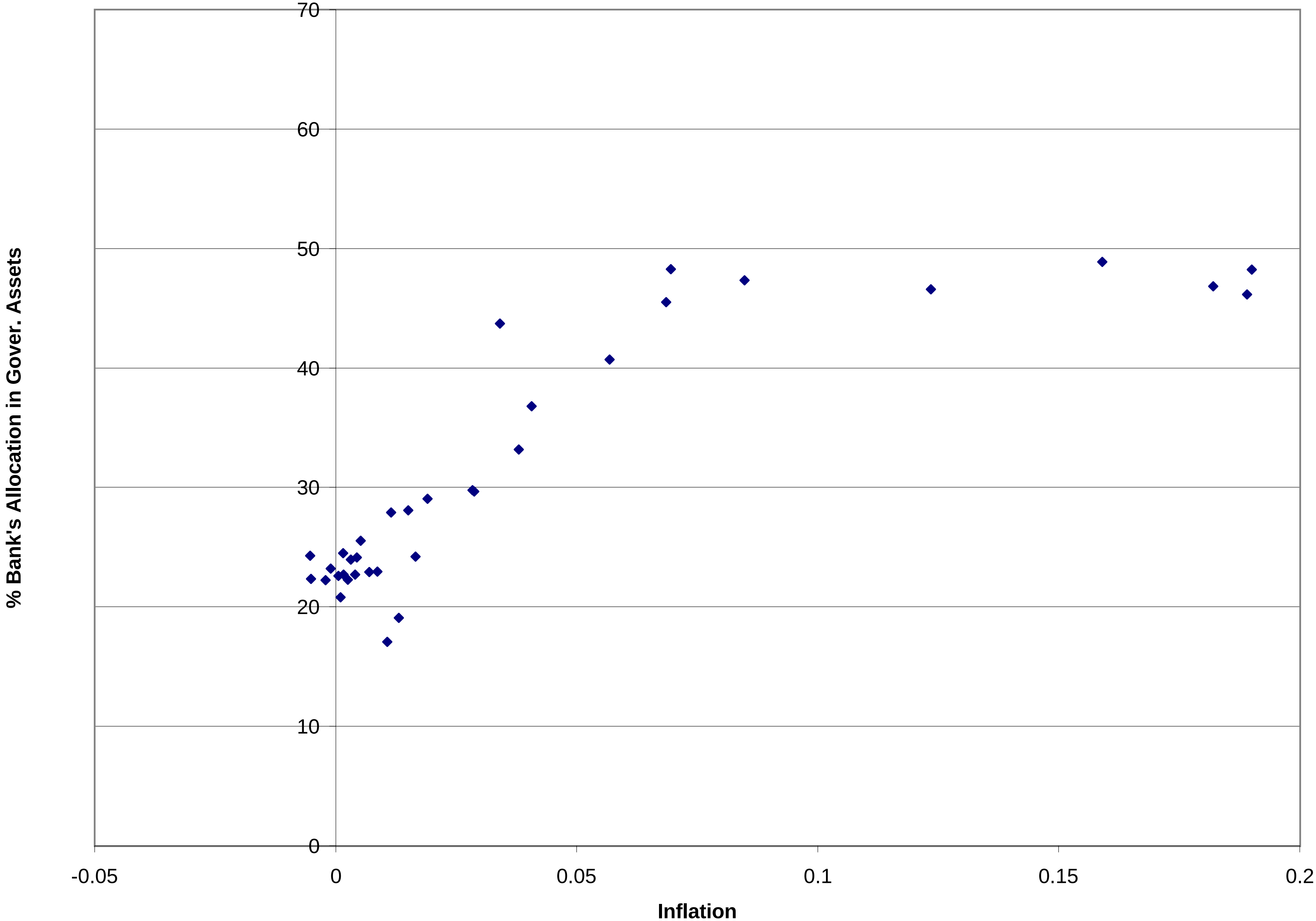


Figure 2.4
Bank's portfolio allocation and Inflation



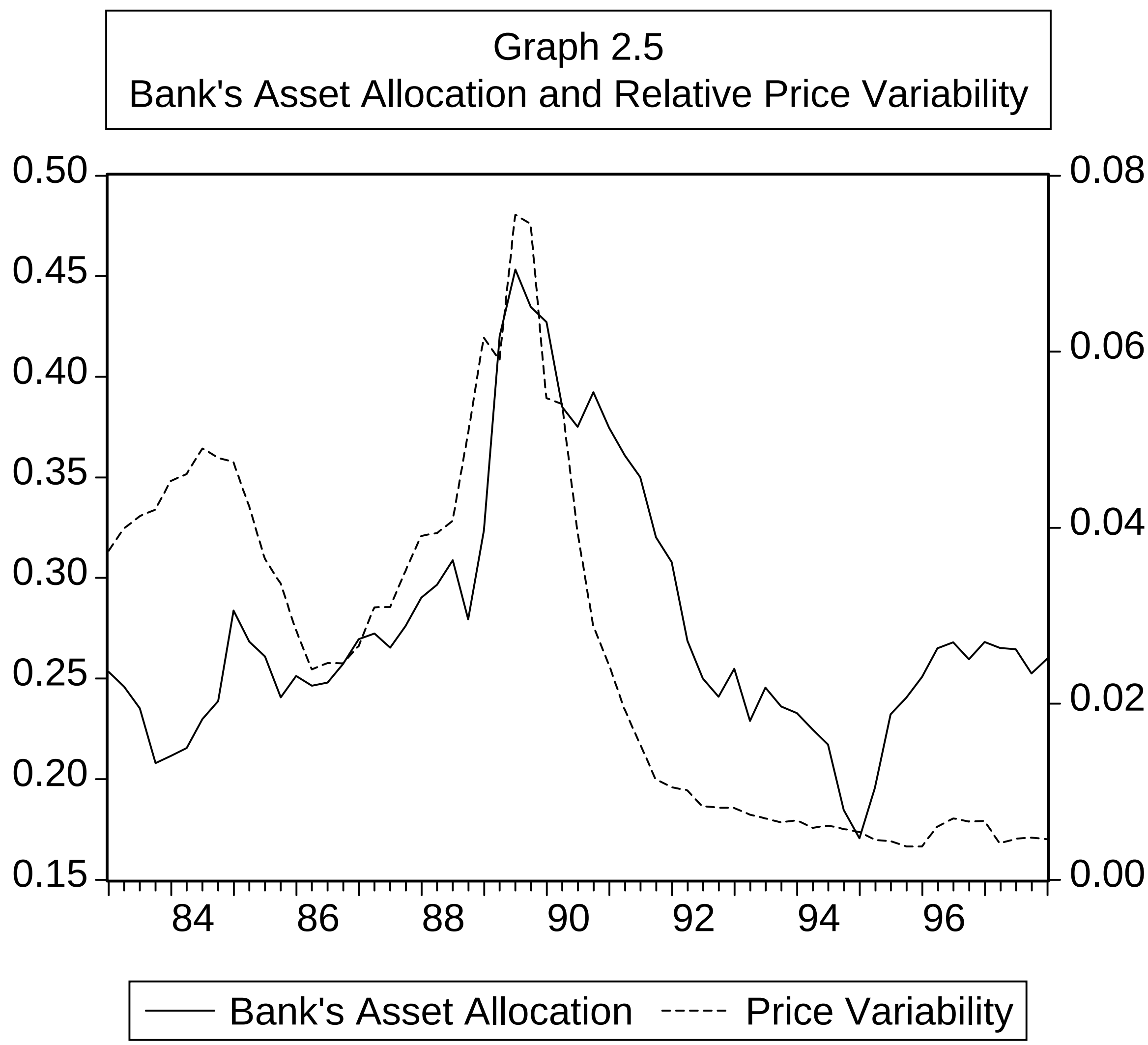
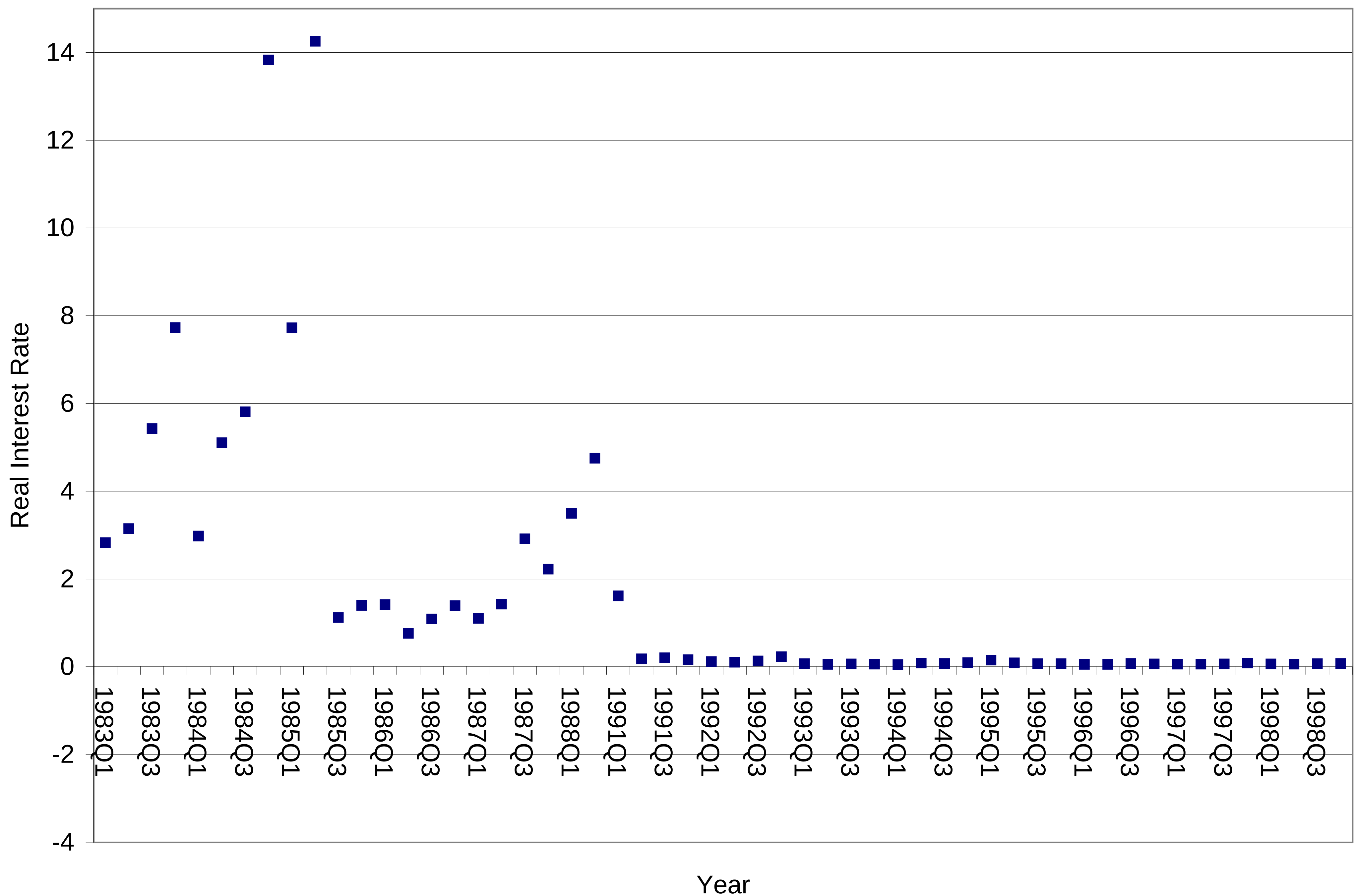
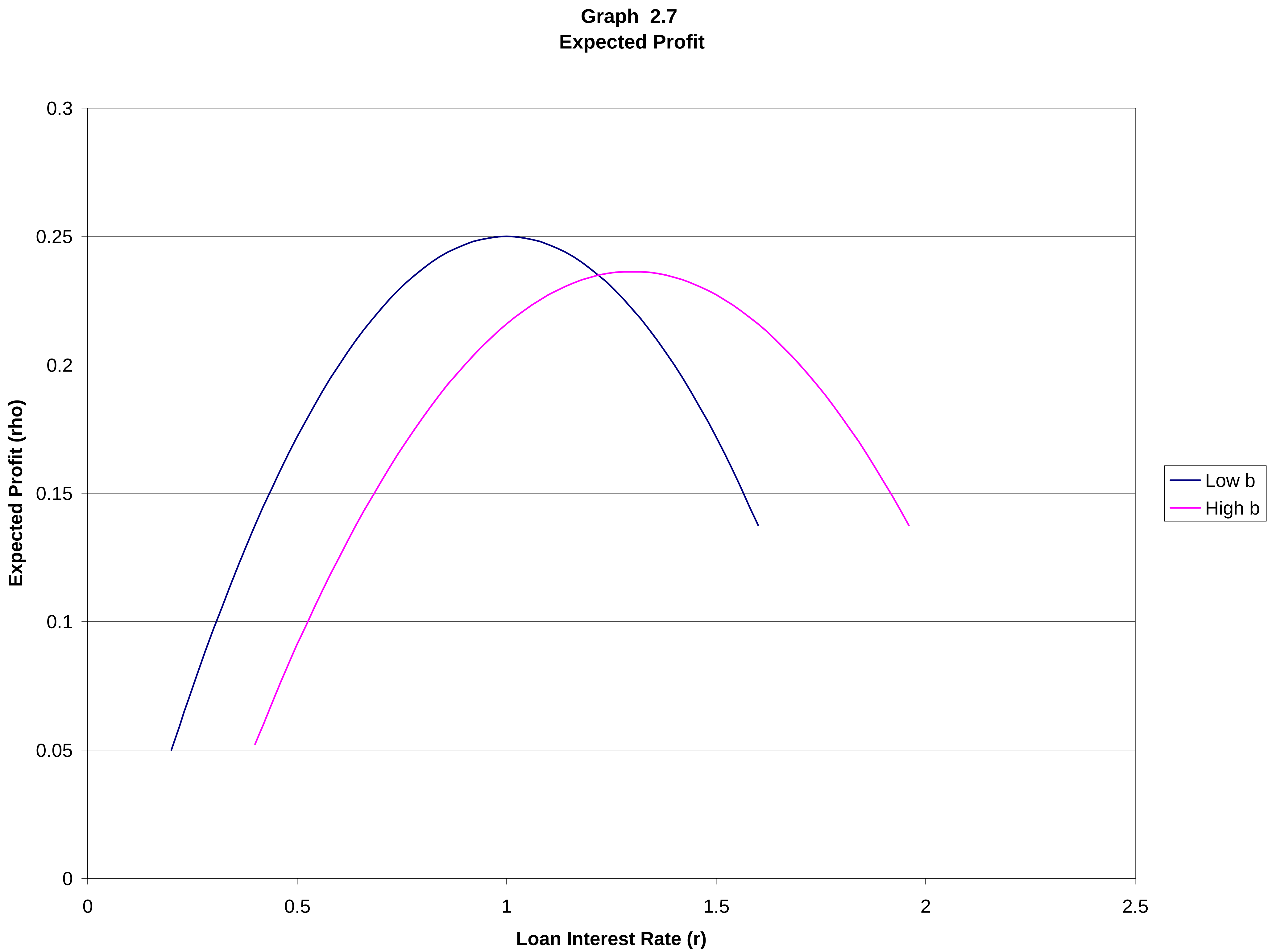

Graph 2.5
Bank's Asset Allocation and Relative Price Variability
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.08
0.06
0.04
0.02
0.00
84
86
88
90
92
94
96
Bank's Asset Allocation
Price Variability

Figure 2.6
Real Interest Rate




Graph 2.7
Expected Profit
Expected Profit (rho)
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
Loan Interest Rate (r)
Low b
High b

Graph 2.8
Cut-Off Cost versus (mu-i) for Different Inflation Risk