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Departamento de Economia, Administração e Contabilidade
Mestrado em Economia - FEA\IPE\USP

The Great Depression in Brazil

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Outubro de 2012

São Paulo

Versão Corrigida

(Versão original disponível na Faculdade de Economia, Administração e Contabilidade)

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The Great Depression in Brazil

Dissertação apresentada ao Departamento de Economia da Faculdade de Economia, Administração e Contabilidade da Universidade de São Paulo como requisito para a obtenção do título de Mestre em Ciências.

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FICHA CATALOGRÁFICA

Elaborada pela Seção de Processamento Técnico SBD/FEA-USP

Astorino, Eduardo Sanchez

The Great Depression in Brazil / Eduardo Sanchez Astorino –
São Paulo, 2012.

48 p.

Dissertação (Mestrado) - Universidade de São Paulo, 2012

Orientador: Mauro Rodrigues Junior.

1. Economia Internacional 2. Grande Depressão 3. Macroeconomia

I. Universidade de São Paulo. Faculdade de Economia, Administração
e Contabilidade II. Título.

CDD - 337

À minha família

AGRADECIMENTOS

Em primeiro lugar agradeço minha família por todo o apoio e suporte ao longo desses três anos. Agradeço a meus pais, Reinaldo e Magali, pelo exemplo de dedicação e, acima de tudo, força perante os desafios da vida. Agradeço a meus irmãos, André e Paula, pela ajuda nas horas difíceis.

Agradeço a meu orientador, Mauro Rodrigues Junior, pelo auxílio prestado ao longo desses três anos, por sua paciência e pelo exemplo de excelência na atividade discente e de pesquisa. Meu contato com ele foi essencial para me transformar em um economista melhor.

Aos professores Carlos Eduardo, Giuseppe Fiori e Renato Colistete pelos seus comentários. Agradeço também ao professor Pedro Garcia Duarte pelos diferentes auxílios prestados ao longo dos anos. Ao professor José Flavio Motta, por ter acendido meu interesse pela história econômica. Aos professores Carlos Azzoni e Márcio Nakane, pelo exemplo de docência e dedicação que eles me deram.

Aos amigos do mestrado que tornaram esta a experiência mais memorável da minha vida. À Anna, Murilo, Sarah, Rafael, Lia, Paula, Danilo, João, Thiago, Victor. Sem vocês eu não teria conseguido terminar esta etapa.

Aos monitores Thomaz e Dejanir, pelo exemplo de dedicação e pela sua amizade. Nosso contato acadêmico moldou minhas visões sobre economia. À Paula Pereda, pelo seu exemplo e amizade.

Um agradecimento especial à Denise, cujo auxílio e compreensão foram essenciais para que eu completasse esta empreitada.

Aos meu “bixos” de mestrado Laura, Vivian, Renata e Rafael, que me ajudaram enormemente nesta etapa final. Ao Leonardo, Lilian e Gabriel, meus alunos de monitoria, por terem me ajudado a virar um professor melhor.

Por fim, agradeço ao apoio financeiro do IPE, CNPq, Fapesp e Fundo Sasakawa.

The central problem of depression-prevention has been solved, for all practical purposes.

Robert Lucas

RESUMO

Este trabalho objetiva explicar a performance da economia brasileira durante o período da Grande Depressão. Nós propomos um modelo de equilíbrio geral com economia aberta no qual o governo brasileiro consegue melhorar os termos de troca ao se aproveitar da posição monopolística do Brasil nos mercados internacionais de café. Ele queima uma parcela da produção de café para influenciar os preços internacionais, assim contendo o impacto da Grande Depressão sobre a oferta de bens de consumo e investimento importados da economia doméstica. Nós descobrimos que o mecanismo de queima do café é capaz de melhorar a performance da economia sob algumas de nossas hipóteses sobre a parcela de café que é destruída. Nossos modelos também se ajustam com diferentes graus de sucesso aos dados sobre os preços internacionais do café.

JEL: E65, F41, N16

Palavras-chave: Economia internacional, Grande Depressão, Macroeconomia.

ABSTRACT

This work aims to explain the performance of the Brazilian economy throughout the period of the Great Depression. We propose a general equilibrium, open economy model in which the Brazilian government can improve the terms of trade by taking advantage of Brazil's monopolistic position in international coffee markets. It burns a share of coffee production in order to influence international prices, thus containing the impact of the Great Depression on the domestic economy's supply of foreign consumption and investment goods. We find that our coffee burning mechanism is capable of improving the performance of the economy for some of our assumptions about the share of coffee that is destroyed. Our models also fits with different degrees of success the data on international coffee prices.

JEL: E65, F41, N16

Keywords: International economics, Great Depression, Macroeconomics

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1. Introduction

This work aims to explain the performance of the Brazilian economy throughout the period of the Great Depression. The key issue that we wish to address is that, despite a high level of vulnerability to international shocks (caused by an apparent dependence on foreign markets), the Brazilian Great Depression displayed a relatively small drop in output, as well as a fairly short recovery period.

In order to analyze this problem, we propose a general equilibrium, open economy model with a key assumption: the government is able to influence the terms of trade by destroying the only tradable commodity that the domestic economy produces. In our model, this commodity is coffee. There are important works in the Brazilian historical literature, such as Furtado (2007) and Delfim Netto (1959), that propose that the price-defence mechanism, instituted in order to maintain international coffee prices at a high level, was in some form or another responsible for insulating the Brazilian economy against the Great Depression shock. This is, to our knowledge, the first attempt to conduct a quantitative assessment of this question.

This work is organized as follows. In Section 2. we present the views of some of the main studies on the functioning of the Brazilian economy during the Great Depression, as well as the available data for this time period; in Section 3. we present a macroeconomic literature that serves as a basis for our analysis, by applying the tools of the neoclassical growth model to explain episodes of severe economic recession; in Section 4. we describe our general equilibrium, open economy model; in Section 5. we present the results of our simulations; finally, in Section 6. we present our conclusions. The description of data sets and the solution of our model are in the Appendix.

2. Background

The Great Depression of the 1930s did not affect all countries in the same way. While most Western economies suffered a drop in output, the size and persistence of this drop varied greatly. The iconic Depression experience was the one suffered by the United States, in which output fell by about 30% from 1929 to 1933, and employment fell by 25% ¹; the Canadian economy also suffered large drops in output (41%) and employment (31%) ²; in Europe, we

¹Cole & Ohanian (2007)

²Amaral & MacGee (2002)

observe similar drops in Germany (33%³), Italy (25%⁴) and France (13%⁵).

The Brazilian experience with the Great Depression contrasts sharply with that of the countries mentioned above. Using the available macroeconomic data (which we describe in the Appendix), we can verify that the Brazilian Great Depression was characterized by a relatively moderate fall in output, as well as a short recovery period.

Figure 1: Per Capita GDP estimates and trend (1929 = 100)

Source: IBGE (2006), Table I.1.1

In Figure 1 we have Brazilian per capita GDP from 1929 to 1939, as well as its historical, linear trend, calculated for the period 1901 – 1939. As we can see, Brazil seems to not have been affected as strongly by the Great Depression of the 1930s. The largest drop occurs in 1931, when per capita GDP falls by 7.5% from its 1929 level, a relatively small amount when compared to the Western economies mentioned above. Also, by 1932 the economy had already recovered its pre-Depression level, with the return to trend occurring in 1933.

The fact that so many countries were affected by the Great Depression, and that their responses were so varied, leads us to consider possible international transmission mechanisms. There is data that seems to support the idea that the Brazilian economy was very dependent

³Fisher & Hornstein (2002)

⁴Perri & Quadrini (2002)

⁵Beaudry & Portier (2002)

on the foreign sector, and thus extremely vulnerable to external shocks. There is also evidence that Brazil enjoyed a monopolistic role in international coffee markets. However, we choose to first present the views of important historical studies on the Brazilian economy which support the assumptions of our model. We do this because these studies served as the original basis for determining the workings of the economy we modelled in our work.

In Furtado (2007) we have an account of the Great Depression in Brazil which greatly supports the views of our own model. The author maintains that after the 1929 crash, the coffee sector in Brazil faced difficulties that affected both supply and demand. At the supply side, the fall of international coffee prices was partially offset by the devaluation of the domestic currency, thus maintaining the production of coffee at high levels. On the other hand, the inherently inertial aspect of coffee production meant that an expansion of coffee plantation would maintain the supply at a high level for many years. At the demand side, the Great Depression shock caused a large drop in international coffee prices, however this particular market was price-inelastic, consequently the increase in the demand for coffee was not able to compensate this movement.

At the onset of the Great Depression, coffee producers had expanded their plantations, thus insuring that coffee supply would remain abnormally high for the next ten years. Furtado maintains that the political power of coffee producers implied that the most simple solution to the problem of overproduction, that is, simply allowing the crops to rot instead of harvesting them, would not be used, since it meant that coffee producers would have to pay the cost of the Great Depression shock. Instead, coffee crops were harvested as usual, thus creating the problem of financing their stock. Consequently, the burning of these stocks comes as a natural answer to this problem, once the Great Depression causes a large drop in the international flow of capital, thus diminishing the amount of resources available to finance the stocking of coffee beans for a later sale (in comparison, the destruction of stocks would demand fewer resources).

Finally, Furtado claims that the importance of the coffee sector was not restricted to its direct contribution to national income, but also to all the other economic activities which depended on this sector in some form. Thus, the policy of buying coffee stocks only to subsequently destroy them could be justified as an anti-cyclical measure which aimed at protecting the Brazilian economy from a larger drop in activity that would have occurred if such policy had not taken place. However, it is important to point out that this view is not supported in our model economy: in it, the policy of burning coffee stocks does not maintain the levels of economic activity through some sort of multiplicative effect, but by the effect that it has on the terms of trade of the domestic economy, which itself is highly dependent on the foreign sector for acquiring investment and consumption goods.

One of the most significant and thorough studies on the role of the coffee sector in the Brazilian economy is Delfim Netto (1959). This study is aimed at examining the entire history of coffee production in Brazil, from the second half of the nineteenth century up to the mid-twentieth century, with a special focus on the different forms of government intervention in this market. It is worth discussing this history at this point.

Prior to the 1930s, the Brazilian price-defence mechanism was essentially based on controlling the international supply of coffee through the stocking of harvested beans. The government interpreted (correctly, according to Delfim Netto) that the coffee sector suffered from an over-production problem, which forced international coffee prices to fall along the first years of the twentieth century⁶. Consequently, it would be possible to increase these prices if the government were able to enforce policies which aimed at lowering the output of coffee producers. These specific policies varied over time, from simply prohibiting the expansion of coffee plantations to instead buying their harvest and then storing the beans until outside conditions forced an increase on their market price. Obviously the first measure was potentially difficult to enforce, thus the stocking was chosen as the main supply-control policy prior to the 1930s.

The essential feature of this “solution” to the problem is that its success would serve as an incentive for coffee producers to increase their output, thus deepening the problem of over-production. By implicitly assuring coffee producers that they would be able to obtain a minimal price for their production, the government was merely addressing the short-term aspect of this issue, thus ensuring that any price-defence operation in the future would necessarily be more costly than it was in the past. These costs were substantial: the resources needed to fund this mechanism were loaned from private, foreign banks, and these demanded high interest rates in return (as they viewed the price-defence policy as a very high-risk operation).

Delfim Netto interprets the coffee burning policy of the 1930s as a necessity brought on by the collapse of this mechanism. Up to that point, its success was owed to a combination of favourable shocks on coffee output and international prices. Once the Great Depression shock hits, there is a large drop on international capital flows, thus endangering the sustainability of the defence program based on stocking. Other factors which contributed to the change in government policy were the fact that Brazil had already accumulated a significant debt with foreign debtors due to prior defence operations, and the fact that the 1927/28 and 1933/34 coffee harvests were abnormally large. Since the government was facing a very profound financing problem, the destruction of the coffee stocks comes as a natural solution to this impasse.

⁶According to Villela & Suzigan (1977), the government would have a direct interest in maintaining the international coffee prices at a high level because most of its fiscal revenue was generated by the taxation of imported goods. Consequently, it was important to guarantee that Brazil's import capacity remained high.

Delfim Netto also argues that the burning of coffee stocks could be justified as a desperate measure directed at maintaining the level of economic activity during the Great Depression. The author suggests that a protracted recession in the coffee sector would impact social welfare through a rise in unemployment, which could possibly lead to social chaos. Thus, Netto shares the opinion of Furtado (2007) with regards to the necessity of the coffee burning policy, while maintaining that this policy was merely adjusting the coffee sector in a context in which market incentives were not able to do so⁷. The data on the actual share of burned coffee over total production is reproduced in Figure 2.

Figure 2: Share of burned coffee over total production
Source: Peláez (1972).

If we compare this graph with Figure 4, we see that the first peak of Figure 2 corresponds to 1933, when the Brazilian economy was already engaged in a recovery path and the decline of the United States GDP had finally stopped. The other peak comes in 1937 and is noticeably larger than the first one, reaching a little more than 70% of burned coffee stocks. On average, the Brazilian government burned 26.96% of total coffee production for the 1931 – 1944 period,

⁷Because of the government intervention that maintained international coffee prices at a high level, as well as the policies aimed at facilitating the financing of production, coffee growers were actually faced with incentives to increase their output, despite the fact that international markets would have forced the price of this commodity to drop. In addition, the government had proven itself unable to enforce any sort of restriction on the planting of new coffee plants.

and slightly less (24.72) for the 1929 – 1939 period.

In Delfim Netto (1959) we can also find econometric evidence that supports the assumption that the international coffee market was price-inelastic. The author uses data on retail prices, per capita consumption, per capita earnings and cost of living for U.S. consumers (provided by the Pan-American Coffee Bureau) in order to estimate the price-elasticity of coffee demand. Despite finding a non-significant estimate for the income-elasticity, Netto also finds a statistically-significant estimate of 0.5 for the price-elasticity, meaning that a 1% rise in prices would lead only to a 0.5% drop in consumption. Thus, there is evidence that the price-defence mechanism could indeed maintain the total earnings of coffee producers through the increase in international coffee prices.

The data available to us is able to offer some sort of basis for the assumptions of the studies described above, however there are some caveats we need to consider. The first problem we find in trying to understand how the Great Depression shock was transmitted to Brazil is the fact that we do not have access to all the data necessary to paint a more meaningful picture of the Brazilian economy in the 1930s. As described in the Appendix, the organized production of national accounts started only in 1947. Prior to this date, we need to rely on estimates and a variety of data sets which sometimes were built without any sort of coordination. However, we maintain that the data sets used to support similar studies for the U.S. economy (which form the basis for our modelling strategy) are themselves subject to a certain degree of inaccuracy. This is, unfortunately, an inherent issue when dealing with a time period so removed from our present.

One of the main assumptions of our model is the role of the foreign sector in the Brazilian economy. We maintain that Brazil displayed a very high level of dependence on foreign markets. We can find data sets on industrial output and composition in Malan et al. (1977) that gives some basis to this assumption, such as the share of imported goods over total supply of a few industrial sectors, for selected years. Despite the lack of annual data for the period we wish to study, this limited data set gives us some idea of the domestic dependence on imported goods. According to this data, the average share of imported industrial goods over total industrial supply is 44.02% for the period 1920–1929, and remains relatively high when we consider the period 1920–1939, at 33.51%⁸.

We can also find data on the composition of these industrial imports, but only for selected years. We reproduce this data for 1937/39 in Table 1. As we can see, non-durables and capital goods are the main categories of imported industrial goods, representing 67.2% of total imports.

⁸Malan et al. (1977, p. 287), Table V.8.

We unfortunately are unable to find data on how the composition of industrial imports changed over the Great Depression years, but data on the sectoral decomposition of industry for 1919 and 1939 shows that the share of imported capital goods over total supply of this genre increased over time. The most significant category of capital goods was transportation, which represented 93.3% in 1919. Of these, 53.5% was not produced internally. This share increased to 56.2 by 1939. For mechanical goods, this share was 96.7% for 1919 and decreased to about 80% by 1939⁹.

Table 1: Share of selected sectors on total imports

	1937/39 (%)
Non-durable consumption goods	35.7
Durable consumption goods	6.2
Prime materials	16.5
Fuels and lubricants	10.1
Capital goods	31.5
Total	100

Source: Malan et al. (1977), Table II.7

There is data on the coffee sector that supports some of the assumptions of works such as Furtado (2007) and Delfim Netto (1959). It is safe to say that this commodity enjoyed a very important role in the Brazilian foreign trade: from 1901 to 1939 coffee exports accounted for 57.20% of total exports and 67% of agricultural exports, on average (the latter accounted for 85% of total exports)¹⁰.

We can also attest that Brazil enjoyed a very important position in the international market for coffee. From 1901 to 1929 Brazil was responsible for 71% of the world coffee supply, on average (according to the data present on Martins & Johnston (1992), see the Appendix). During the 1930s, this average suffers a slight drop, going to 66%, however Brazil remains the most important individual supplier of coffee to international markets¹¹.

In Figure 3 we have exports price for coffee, corrected by the U.S. consumer price index from the Bureau of Labor Statistics¹². The behavior of coffee prices suffers a severe impact during the Great Depression, as we can see in Figure 3. Between 1929 and 1931 they dropped by

⁹Malan et al. (1977, p. 281), Table V.6.

¹⁰IBGE (2006). The data is described in the Appendix.

¹¹In Delfim Netto (1959), the author argues that Colombia benefited directly from Brazil's price defence policy, while the African colonies owe their increased importance in the world coffee production to the generalized increase in international tariffs which followed the 1929 crash (also noted in Perri & Quadri (2002)).

¹²Available at <ftp://ftp.bls.gov/pub/special.requests/cpi/cpiiai.txt>.

Table 2: Brazilian exports

Year	Total	Agricultural	Coffee	Coffee Total exports	Coffee Agricultural exports
1929	94.831	84.663	67.307	0.71	0.79
1930	65.746	54.225	41.179	0.63	0.76
1931	49.544	41.900	34.104	0.69	0.81
1932	36.630	32.560	26.238	0.72	0.81
1933	35.790	32.011	26.168	0.73	0.82
1934	35.240	31.159	21.541	0.61	0.69
1935	33.012	28.132	17.373	0.53	0.62
1936	39.069	33.079	17.786	0.46	0.54
1937	42.530	34.332	17.887	0.42	0.52
1938	35.945	28.915	16.192	0.45	0.56
1939	37.298	27.470	14.892	0.40	0.54

Source: Motta et al. (1990), Agriculture and Foreign Sector tables

almost 60%, and only displayed a moderate improvement before once again falling to roughly 30% of its 1929 value by the end of the decade.

3. Literature review - Great Depressions from a neoclassical perspective

In this section we expand upon the macroeconomic literature that serves as a guide to our modelling strategy. We will see that the neoclassical growth model presents interesting answers to questions of depth and length of episodes of severe economic recession such as the Great Depression of the 1930s. We will also describe the main applications of this research program and how they apply to the problem we wish to address.

The late 1990s marked the beginning of a research program which studied the Great Depression with the tools provided by the neoclassical growth model. A particularly important paper in this line of study is Cole & Ohanian (1999), in which the authors present a growth model calibrated for the U.S. economy from 1929 to 1939. Their objective is to generate an artificial economy in which the depth and the duration of the depression episode are similar to the ones we observe in the data. By utilizing a combination of large real and monetary shocks, Cole and Ohanian are able to account for the initial economic downturn which lasts from 1929 to 1933, however they find that their model predicts a fast recovery from 1934 onward, while empirical data shows that output remained below its 1929 level even 10 years after the crash.

Figure 3: Coffee prices (1929 = 100)

Source: IBGE (2006), Foreign sector tables, Table 8; Consumer Price Index-All Urban Consumers, BLS (2012).

The authors conclude their study by pointing that this discrepancy between the data and their artificial economy is likely caused by the set of policies known as the New Deal, which prolonged the depression by hampering the adjustment of real wages and by facilitating the formation of monopolies and cartels.

This particular research question is further continued in Ohanian (2009), in which the author gives more indications to suggest that the persistence of the Great Depression in the United States was due to public policies concerning the labor market. President Hoover's policies were responsible for an increase in the bargaining power of unions, and in order to counter the fear of unionization the President created a program that offered industrial firms a measure of protection from unions in exchange for the payment of higher wages. Ohanian develops a model in which these policies account for the fact that the Great Depression was marked by a substantial and chronic unemployment, as well as real wages far above normal in key industrial sectors.

This line of research sparked a new interest in using the real business cycle framework to study historical cases of severe recession. Until that point, most of the literature focused on the

role played by monetary factors (like deflation and the adherence to the Gold Standard¹³). In fact, Edward Prescott himself did not believe that the theory of real business cycles was suited to modelling the Great Depression¹⁴. After the article by Cole and Ohanian there appears to be a change in this point of view, and we begin to see a number of articles which adopt their methodology in order to answer similar questions about the Great Depression in the U.S., as well as in other countries.

In 2007, Patrick Kehoe and Edward Prescott collected a number of these articles in the volume *Great Depressions of the Twentieth Century*¹⁵. The topics covered range from the Great Depression in the United States, United Kingdom, Italy, France and Germany, to the “lost decades” in Latin-America (the 1980s in Brazil, Mexico, Argentina and Chile) and Japan (the 1990s), and, finally, to similar cases of deep recessions in Finland, Switzerland and New Zealand¹⁶.

The methodology followed by the articles contained in Kehoe & Prescott (2007) begins with the use of growth accounting to decompose changes in output in changes in productions factors (usually capital and labor) and in the efficiency with which these factors are combined in order to generate output (the Total Factor Productivity, TFP). This variable is measured by first assuming a production function which uses technology and production factors to generate output, which usually takes the shape of a Cobb-Douglas production function¹⁷:

$$Y_t = Z_t K_t^\alpha N_t^{1-\alpha}, \quad (3.1)$$

in which Y_t is output, K_t is capital, N_t is labor (measured in working hours) and Z_t is total factor productivity. If we have measures of output, capital and working hours, as well as a value for the parameter α (which is calibrated in order to reproduce the share of capital in income), we can then determine Z_t as a residual in equation (3.1).

By its definition, TFP represents not only technological factors, but also any factor that affects the efficiency of production but is exogenous from the perspective of the producer. One example of such factor is government policy: through fiscal, monetary and institutional instru-

¹³Friedman & Schwartz (1971)

¹⁴Prescott understood that RBC models could only be made to explain economic fluctuations under periods of financial and political instability. For a reference on this issue, see Vroey & Pensieroso (2006).

¹⁵Most of the articles collected in this volume were originally published in 2002, in a special issue of the *Review of Economic Dynamics*.

¹⁶It is heavily emphasized throughout the articles collected in Kehoe & Prescott (2007) that historical episodes similar to the Great Depression are actually more common than they seem at first, and that many countries have experienced them recently.

¹⁷The fact that the shares of income paid to factors seems to remain constant over time is what motivates the use of the Cobb-Douglas production function.

ments (such as antitrust and labor regulations, restrictions on international trade *etc.*), public policy is able to severely affect economic outcome. This is, in fact, the interpretation used by most of the articles in Kehoe & Prescott (2007).

As such, two of the main findings of this research program are:

1. For the United States, the total factor productivity is important in explaining the initial downturn of a Great Depression. In other words, these depression episodes usually begin with a technological shock that affects the marginal productivity of labor and capital, which leads agents to alter their optimal decisions between labor and non-market activities¹⁸. However, TFP presented a very steep recovery a few years after the 1929 shock, which means that this factor alone cannot explain the sluggish recovery of most Western economies during the 1930s;
2. Public policy was fundamental in determining the duration of the depression episode, through channels such as nominal wage stickiness in the labor market, imperfect competition and restrictions to international trade. Therefore, a model with frictions affecting these margins is able to account for the recovery pattern that we observe in the 1930s.

One of the studies contained in Kehoe & Prescott (2007), by Fabrizio Perri and Vincenzo Quadrini (originally published in Perri & Quadrini (2002)), deals with issues very similar to our own. In this article, the authors are interested in studying the effects of wage rigidities and trade restrictions in the Italian economy during the Great Depression. According to Perri and Quadrini, the overall impact of the Great Depression in Italy was smaller than in other countries, but the fall in industrial production was similar to the one observed internationally, while the farm sector (proportionally larger than the industrial sector) was mostly unaffected. Since a large proportion of investment goods to the industrial sector came from international trade, it is natural to attribute this fall in industrial output to the “tariff war” which took place in the 1930s¹⁹.

Another feature of the Italian Great Depression was the stability of real wages. As mentioned above, one of the results of this literature is that nominal wage stickiness is an important factor in explaining the duration of depressions, however the rigidity of nominal wages *per se* does not seem to be important for the Italian case. That is because nominal wages present a relatively large level of variability during the 1930s. Perri and Quadrini argue that this was

¹⁸This finding is consistent with the rest of RBC literature. In Prescott (1986), for example, Prescott finds that a simple one-sector model with only a plausible stochastic process for technology is able to account for 70% of post-war business cycle fluctuations in the U.S.

¹⁹A number of countries adopted stricter policies on international trade after the 1929 shock, such as increased tariffs, import quotas and currency control

caused by the influence of the fascist regime, which seemed to control nominal wages in order to keep real wages in their 1929 level²⁰. This, coupled with a decrease in daily work hours, was responsible for an increase in the cost of labor, thus contributing to the fall in industrial output.

Their model consists of households which consume leisure and a CES aggregation of tradable and non-tradable goods. They also decide on the amount of capital they will accumulate, using an investment technology which also presents a constant elasticity of substitution between tradables and non-tradables. The firms on both sectors produce output according to a Cobb-Douglas production function, and the public sector finances lump-sum transfers through an import tariff. Finally, the equilibrium in the foreign market is determined by imposing that real demand for imports is equal to real international demand for exports (which amounts to assuming the existence of two symmetric countries).

Despite the authors' concern with questions of trade and wage rigidities, their questions of transmission of international shocks is in fact similar to ours, and so we use their general setup in order to construct our own model. In the next section we define the features of our model and discuss the results of our simulations.

4. An open economy, general equilibrium model

In this section we describe the model which we use to analyse the role of the coffee price-defence mechanism in the Brazilian Great Depression. We present the model's equations and leave the derivation of important results (such as the steady-state of our economy) to the Appendix. Our environment is a non-stochastic, perfect foresight economy which resembles very closely the one presented in Perri & Quadrini (2002), except for a few key assumptions:

1. In our model the domestic economy produces a general good which can be used for consumption and investment, as well as a coffee good which can only be exported to the rest of the world. The exports' revenue is used to import general goods;
2. Firms do not use labor as a production factor, only capital. This condition can also be interpreted as assuming that labor is a specific production factor that cannot be moved between sectors²¹;
3. The government uses a lump-sum tax to finance its price-defence mechanism;

²⁰This was accomplished, in some part, due to a remarkable lack of resistance to wage cuts by Italian workers.

²¹In this case, the profit of the firms is zero, and households earn a fixed wage for their labor in each sector.

4. The domestic economy is the only producer of coffee in the world, but producers themselves do not act as monopolists in international markets. Instead, the government buys their coffee output and resells only a share to foreign consumers, destroying the remaining share (at no cost).

With these changes in mind, we now describe our model.

4..1 Households

Households maximize their lifetime utility, given by

$$\sum_{t=0}^{\infty} \beta^t U(C_t), \quad (4.2)$$

where β is the intertemporal discount factor (with $0 \leq \beta \leq 1$), the subscript t denotes the time period (time is assumed to be discrete) and the period utility function is given by

$$U(C_t) = \log(C_t). \quad (4.3)$$

Households consume a combination C_t of domestic and foreign consumption goods. Following Perri & Quadrini (2002), this combination is a constant elasticity-of-substitution (CES) aggregation function whose formula is

$$C_t \equiv [\alpha_d C_{d,t}^{\frac{\sigma-1}{\sigma}} + (1 - \alpha_d) C_{m,t}^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}, \quad (4.4)$$

where $C_{d,t}$ and $C_{m,t}$ are domestic and imported consumption goods, α_d is a share parameter for domestic consumption and σ is the elasticity of substitution between $C_{d,t}$ and $C_{m,t}$.

We define an analogous aggregate for investment:

$$I_t \equiv [\alpha_I I_{d,t}^{\frac{\mu-1}{\mu}} + (1 - \alpha_I) I_{m,t}^{\frac{\mu-1}{\mu}}]^{\frac{\mu}{\mu-1}}, \quad (4.5)$$

where $I_{d,t}$ and $I_{m,t}$ are domestic and imported investment goods, α_I is the share parameter and μ is the elasticity of substitution between $I_{d,t}$ and $I_{m,t}$.

Households accumulate capital K_t , which can be used in either the general goods or coffee sector without any sort of adjustment cost²². The law of motion for capital is

²²That is, we assume that capital is non-specific.

$$K_{t+1} = I_t + (1 - \delta)K_t, \quad (4.6)$$

where δ is the depreciation rate

Households receive a rental rate denoted by r_t for their capital stocks, and pay a lump-sum tax denoted by τ_t . As such, their budget constraint is

$$P_t C_t + P_{I,t} I_t + \tau_t \leq r_t K_t + \pi_t, \quad (4.7)$$

where P_t and $P_{I,t}$ are Dixit-Stiglitz price aggregates (as defined in the Appendix) and π_t is firm's profits (we assume the price of imported goods as the numéraire, as such all quantities must be understood in terms of imported goods). Households face the problem of choosing C_t and I_t in order to maximize (4.2) subject to (4.7), and then choosing $C_{d,t}$, $C_{m,t}$, $I_{d,t}$ and $I_{m,t}$ based on its solution for C_t and I_t . The first-order conditions are displayed in the Appendix.

4.2 Firms

Firms choose capital in order to produce general goods and coffee, according to the production technology

$$Y_{i,t} = F(K_{i,t}) = K_{i,t}^{\gamma_i}, \text{ where } i = g, c \quad (4.8)$$

where γ_i is the production parameter for general or coffee goods ($i = g, c$, respectively). Firms maximize their profit function

$$\pi_{i,t} = P_{i,t} F(K_{i,t}) - r_t K_{i,t}, \text{ where } i = g, c, \quad (4.9)$$

where $P_{i,t}$ is the price of their respective outputs. Notice that the rental rates are the same in both sectors: since households only care about the amount of total capital they accumulate, they would only carry both types of capital in equilibrium if their rental rates were the same.

It is assumed that the general goods firms sell their product exclusively to the domestic economy, while coffee firms sell their product only to the foreign market.

4..3 Government

The role of government in our economy is to maintain a price-defence mechanism for the coffee sector which involves buying their output at market prices $P_{c,t}$ and burning a share $1 - \lambda_t$ ($0 \leq \lambda_t \leq 1$) of this coffee stock before selling the rest (that is, λ_t) to international markets, also at market prices. It does so in order to exert some form of pressure in the international price of this commodity. We assume that government is unable to finance its spending through bonds, thus whenever $\lambda_t > 0$ its spending will be greater than its revenue. In order to cover this difference, the government levies a lump-sum tax on the economy. As such, its budget constraint is

$$P_{c,t}Y_{c,t} = \lambda_t P_{c,t}Y_{c,t} + \tau_t. \quad (4.10)$$

The share λ_t is decided exogenously in our simulations.

4..4 General equilibrium

In order to close our model, we need to define the equilibrium of all its markets. We start with the foreign sector. We assume that there is no international mobility of capital, as such the equilibrium in the foreign sector is given by the balance in the trade account:

$$M_t = P_{c,t}X_t, \quad (4.11)$$

where M_t is total imports and X_t is exports (remember that we assume imported goods as the numéraire, consequently their price is normalized at 1). The domestic supply of exported goods must equal the foreign demand, which we assume to be an isoelastic function of foreign income and coffee prices. The coffee supply is the share of government stocks that wasn't burned, $\lambda_t Y_{c,t}$. As such, we must have that

$$\lambda_t Y_{c,t} = X_t^d, \quad (4.12)$$

where X_t^d is foreign demand for coffee.

The mechanism of our model works as follows. Foreign income shocks will impact the international demand for coffee, thus impacting the amount of coffee that can be sold at any given price. If the government does not burn a share of coffee output, then this is truly a given price, and this foreign shock is transmitted to the domestic economy through its effects on the

terms of trade. If foreign income drops, the domestic economy will not be able to import as many goods as before, and thus consumption and investment will fall.

The coffee burn can possibly invert this situation due to the fact that the domestic economy holds a monopoly of coffee production. By destroying a share of coffee production, the government can force an increase in the terms of trade, thus improving the economy's access to foreign goods.

We also need to define the specific resource constraints for each type of good. The demand for imported consumption and investment goods must equal the domestic economy's imports:

$$M_t = C_{m,t} + I_{m,t}. \quad (4.13)$$

Likewise, the demand for domestic goods must equal its production:

$$Y_{g,t} = C_{d,t} + I_{d,t}. \quad (4.14)$$

The households' capital stock must equal the demand for the different types of capital by firms:

$$K_t = K_{g,t} + K_{c,t}. \quad (4.15)$$

4.5 Calibration

We now describe the values we attribute to the deep parameters of our model. A significant part of the calibration comes from the original study of Perri & Quadrini (2002), however we can also find good estimates for some of our parameters in different sources.

Following Perri & Quadrini (2002), we set the inter-temporal discount factor β at 0.96. The depreciation rate is set at 0.10, much like in the rest of the macroeconomic literature. The elasticity of substitution σ between domestic and foreign consumption goods is set at 0.8; the corresponding elasticity for investment goods, μ , is set at the same value. We set the production function parameter equal to 0.45 on both sectors.

The share parameters are calibrated as follows. We set $\alpha_I = 0$ such that the investment good is composed entirely of imported. As mentioned above, the data on the share of imported capital goods leads us to believe that this is not such a radical assumption. We cannot follow Perri & Quadrini (2002) in order to calibrate α_d because their methodology also relies on the

assumption that the trade account balances itself in real terms, with $M_t = X_t$. We set $\alpha_d = 0.5$, but we test other values and find no significant change in the model's behavior.

One of the most important parameters in our model is the price elasticity of coffee demand. The idea that the burning of coffee stocks would be able to counter the effects of the international Great Depression shock only makes sense because of two assumptions: Brazil's role as a monopolist in international markets and the inelasticity of the international demand for coffee. We calibrate this parameter according to Delfim Netto (1959), which gives us an estimate of 0.5 for this elasticity, as mentioned above. Unfortunately in Delfim Netto (1959) the author discovers a non-significant value for the income-elasticity of coffee demand, so we set it equal to 1 (we specify below the actual coffee demand used in our study).

5. Simulations

We now describe the different sets of simulations we run in our model in order to study the dynamic adjustment of the Brazilian economy to the Great Depression shock. We are interested in studying the transition of our economy between two different steady states, pre- and post-Depression. During the transition, our economy is subject to the behavior of foreign income. As described in the Appendix, our measure of foreign income is a weighted average of per capita GDP for Brazil's most important trading partners. We use data from IBGE (2006) on Brazil's foreign trade by country of destination/origin in order to find each country's share of Brazilian foreign trade. We then use the data from Maddison (2012)²³ on per capita GDP to build our measure of foreign income. We now describe the benchmark which will be used as a comparison to the rest of the experiments.

Throughout our simulations, we assume that the isoelastic demand for coffee takes the following shape:

$$X_t^d = \frac{\beta_0 Z_t^\theta}{P_{c,t}^\vartheta}, \quad (5.16)$$

where β_0 is an intercept parameter, Z_t is foreign income, θ is the income-elasticity of demand and ϑ is the price-elasticity of demand.

²³ Available at <http://www.ggdc.net/MADDISON/oriindex.htm>.

5..0.1 A benchmark economy

In order to have a basis with which to compare our experiments, we first simulate an economy in which the government does not interfere in the coffee market in order to maintain international prices. In this case, the Great Depression shock is directly transmitted to the domestic economy. This is accomplished by simulating the behavior of our economy when $\lambda_t = 1 \forall t$. The results of these simulations are presented in Figures 4 and 5. We first analyze the response of GDP.

Figure 4: Simulated and real GDP (1929 = 100)

As we can see, the benchmark economy produces a very different behavior than the one we observe in the empirical series. In our simulations, the economy's activity levels continue to drop until 1932, one year after the turning point of the Brazilian Great Depression. Its fall is also a lot more dramatic: by 1932 GDP had dropped by more than 40%, thus outdoing even the 25% drop in the U.S. economy. The economy begins to recover at this point, but the recovery does not pick up strength until the following year, when the U.S. economy itself begins to turn.

The pattern of coffee prices also deviates from the one presented by the Brazilian economy. The model actually predicts a smaller drop in coffee prices than we observed in reality, with

Figure 5: Coffee prices (1929 = 100)

a trough observed in 1932. In this case, coffee prices drop by about 43% from its 1929 level, while in reality they fell by almost 60% before displaying a slight improvement. However, the actual prices suffer a long-term drop throughout the 1930s, while the model predicts a slight increase in coffee prices from 1929 to 1939.

We can also observe a pattern of capital substitution along the economy's adjustment. Following its departure from the steady state, the economy begins to increase its share of capital in the general goods sector in comparison to the coffee sector. From 1929 to 1939, the amount of capital in the general sector increases by almost 2% in relation to the capital in the coffee sector. This leads us to believe that the Great Depression affects our economy by initiating a process of substituting the production of coffee for general goods.

5..0.2 Introducing the coffee burning mechanism

There are several ways to introduce the coffee burning mechanism in our model. We have data from Peláez (1972) on the share of coffee production burned by the government, from 1931

to 1944, which we can input in our model in place of the variable λ_t ²⁴. We can then observe how the domestic economy adjusts to the movements of foreign income when they are accompanied by the empirical behavior of the coffee burning policy.

Our subsequent simulations also involve manipulating the share of burned coffee in order to understand its impact on the recovery of the Brazilian economy during the Great Depression. If we are not able to reproduce that behavior by simply utilizing our data on the actual share of burned coffee over total production, we then try to answer the question of how much more (or less) the government should have burned in order to match the empirical behavior of the Brazilian economy. The results of substituting the empirical coffee burn in our model can be seen in Figures 6 and 7.

Figure 6: Simulated and real GDP - coffee burning mechanism (1929 = 100)

The behavior of our economy changes substantially when we substitute the sequence $\{\lambda_t\}_{t=1}^T$ for its empirical values. As we can see, the simulated economy loses some of its correlation with foreign income when a share of the coffee production is burned. This can be interpreted as a measure of the relative success of this policy, since the burning of coffee stocks seems to have kept the Great Depression shock from being transmitted with full force to the domestic

²⁴To be more accurate, the share of burned coffee corresponds to $1 - \lambda_t$ in our model.

economy.

For 1929 and 1930 there was no burning of coffee stocks, thus the simulated economy behaves more or less in the same way as it did in the benchmark simulation, that is, it underperforms when compared to the real Brazilian economy. From 1931 forward the government begins to burn a share $1 - \lambda_t$ of coffee stocks, however the economy begins to recover prior to that, in 1930, one year before the beginning of the empirical recovery process. Between 1931 and 1932 the simulated economy actually out-performs the actual economy, when the share of burned coffee grows. At 1933 the government burns its largest share so far (46% of that year's production) and the simulated economy reaches a peak, only to begin a descent that is caused by the government burning smaller shares of coffee output. From 1935 onwards this tendency changes and the simulated economy once again begins to recover.

Figure 7: Coffee prices - coffee burning mechanism (1929 = 100)

In this case, the price defence mechanism is able to force an increase in coffee prices along the adjustment to the new steady state. After an initial fall, coffee prices begin to rise as the share of burned coffee rises. Prices suffer a sharp drop in 1933 – 34 when the share of burned coffee is diminished, but once again rise once this share starts to increase.

One interesting feature of this exercise is that we can observe a pattern in the capital ratio

between the general goods and coffee sector which suggests that the defence of coffee prices has the long-term effect of drawing capital away from sectors which would have presented a higher profitability had the defence not taken place. From 1929 to 1939, the ratio of capital on the general goods sector over capital on the coffee sector drops by 15%. By sustaining coffee prices at a high level, the government is able to contain the spread of the Great Depression to Brazil, but this comes at the cost of distorting the market signals that would have allocated the economy's capital to the general goods sector²⁵.

We reproduce a similar exercise now by assuming that the share of coffee burned by the government was constant over time. We set this constant share equal to the average share for the period 1929 – 1939²⁶. The results of this exercise are reproduced in Figures 8 and 9.

Figure 8: Simulated and real GDP - average coffee burning (1929 = 100)

As we can see, simulated GDP now drops by almost 50% before starting a slow recovery process, reaching the end of the decade approximately 15% lower than its 1929 level. However, we seem manage a better fit for coffee prices in this case. They behave very closely to the

²⁵This effect would be even larger had we assumed that capital was specific to each sector, thus increasing the cost necessary to transfer capital goods from one activity to the other.

²⁶We thus take into account the fact that the government only started destroying a part of coffee production in 1931.

Figure 9: Coffee prices - average coffee burning (1929 = 100)

real economy and diverge in 1933, the first peak of coffee destruction. After 1934 both series diverge, with simulated prices showing a better recovery than real prices.

Finally, in order to perform our next experiment, we ignore the empirical series for the share of coffee burned by the government and instead treat λ_t as an endogenous variable. In order to determine its value for each period t , we use the following procedure:

1. If the foreign income, Z_t , is below its linear trend, we define λ_t such that this pressure on coffee prices is nullified by the destruction of coffee stocks. That means defining λ_t in order to maintain $P_{c,t}$ at its pre-Depression levels;
2. If the foreign income is above its linear trend, the government does not destroy any share of the coffee stock, instead setting $\lambda_t = 1$.

Thus, the price-defence mechanism is only put into action if the international crisis threatens the stability of coffee prices. We can observe the effects of this policy in Figure 10.

Figure 10: Simulated and real GDP - endogenous burning share (1929 = 100)

In this case, the simulated economy initially behaves very much like the empirical economy, however they begin to diverge after 1931, the year in which the Brazilian economy started its recovery from the Great Depression. In the simulated economy, GDP continues to drop until 1933, when it begins a very slow process of recovery. The long-term growth of this economy is much smaller than the one we observe in the empirical economy, growing by a mere 3% from its 1929 level. This suggests that the price-defence mechanism was responsible for more than just the stabilization of international coffee prices.

6. Conclusions

In this work we analyzed the impact of the Great Depression in Brazil by proposing a general equilibrium, open economy model in which the government can burn coffee stocks in order to maintain favourable terms of trade and thus maintain the domestic economy's capacity to import consumption and investment goods. We find that the coffee burning mechanism is able to influence the economy's performance through the 1930s in a variety of ways. The empirical coffee burning mechanism has a very big impact on the terms of trade, as well as on GDP.

Once we substitute the empirical share by its average, we find that price behavior has a better fit, however we predict a larger Depression than in the former case. Finally, by creating an endogenous coffee burning mechanism, we can nullify the impact of the Great Depression on prices, but we once again find that the Depression has a larger impact than the one we observed.

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1. Data sets

In this section we describe the data sets utilized in this study. We make some comments on the nature of the data and also describe how we constructed the tables and graphs presented in the text.

As mentioned in the Introduction, the year of 1947 marks the beginning of the systematic production of national aggregates like gross national product, investment *etc.*, first by the “Fundação Getúlio Vargas” (FGV), a private institution, and then by the “Instituto Brasileiro de Geografia e Estatística” (IBGE). However, we unfortunately cannot find officially-produced data sources for the period we want to study. Instead, we rely on estimates produced by different studies in order to construct a more accurate picture of the Brazilian economy in the 1930s.

By far the most important source for the data utilized in this study is Motta et al. (1990)²⁷, which compiles data from different sources for series such as GDP, investment, exports *etc.*, in different levels of aggregation. We begin by describing the GDP estimates contained in this volume. Since the systematic production of data on Brazilian macroeconomic aggregates was started in 1947, any study which addresses a prior period has to rely on estimates which will contain a greater amount of error than the official national accounting statistics²⁸. Motta et al. (1990) describes two categories of studies that attempt to develop GDP estimates for Brazil: *a)* those that estimate economic activity through indicators such as imports, electricity consumption *etc.*; and *b)* those that utilize the available data on different sectors in order to estimate GDP as a weighted average of the activity in these sectors. The studies which utilized the first methodology were subject to numerous criticism concerning their basic assumptions (we cite Carneiro (1966) and Contador & Haddad (1975) as examples of this kind), so Motta et al. (1990) concerns itself only with data series produced under the second methodology. Of these, we will utilize in our study the one produced by Haddad (1978) (originally as a Ph.D thesis at the University of Chicago)²⁹, which estimates the Brazilian Real GDP from 1900 to 1947 based on sectoral output on agriculture, industry, transports and communications, commerce and government. This data set, like most of the data in Motta et al. (1990), is more easily available in IBGE (2006), a compilation of historical statistics from IBGE. The level of per capita GDP presented in Figure 1 is simply a reproduction of this data set, while the linear

²⁷Some of the data in this volume can be more easily accessed in IBGE (2006).

²⁸It is worth mentioning that some authors consider that even the official statistics are subject to a margin of error on the order of 20% (see Morgenstern (1963)).

²⁹It is plausible to say that Haddad’s estimation is the most accurate of all studies reproduced in Motta et al. (1990) due to its amplitude (both in terms of sectoral composition as well as time period) and proximity to the behavior of different industrial indexes.

trend was constructed using the data restricted from 1901 to 1939³⁰.

The data on exports value was also taken from Motta et al. (1990), which reproduces data from Anuário... (1986). In order to construct the series for agricultural exports presented in Table 2 we aggregate the data for the value of sugar, cotton, rubber, cocoa, coffee, tobacco and wheat exports. The share of coffee exports over total and agricultural exports is calculated using this same data set. All of these data sets use thousands of pounds-gold as the unit of measure.

The data for Table 1 was taken from Malan et al. (1977), an important work on the effects of government policy over the industrialization process in Brazil. The authors alert that their decomposition of industrial supply by sector is subject to an unknown amount of double counting, given by the classification of the same industrial activity on more than one category. However, we can still use this data set to indicate the importance of foreign goods in the total supply of industrial output.

The data for world and Brazilian coffee production is taken from Martins & Johnston (1992), which can also be found in IpeaData (2012). We simply divide the latter series by the former in order to find the share of world coffee production which is due to Brazil.

The data on total foreign income is taken from Maddison (2012) and Motta et al. (1990). In order to construct this variable we proceed as follows. We use Table 11.3 of Motta et al. (1990), which gives us the value of total trade (imports and exports) with the main Brazilian trade partners (in pounds sterling). We concentrate on aggregating the information for Great Britain, United States, France, West Germany, Italy, Belgium and Argentina. These countries account for the majority of the total foreign trade (defined by us as imports plus exports), so their income could be considered as a measure of foreign income in our model. In order to find this measure, we define foreign trade weights for each of these countries, based on their share of total trade with Brazil (we scale this measure to take into account the fact that their trade does not account for 100% of foreign trade). We then use these to produce a weighted sum of foreign income with the per capita GDP data from Maddison (2012), who defines this data in terms of International 1990 Geary-Khamis dollars, a measure of purchasing-power-parity.

³⁰The usual approach in determining cycle and trend components in the business cycle literature involves the use of the Hodrick-Prescott (HP) Filter, as detailed in Hodrick & Prescott (1997), however we opt for a linear trend. The HP-Filter is designed to isolate much shorter deviations from trend, such as the ones we observe in the U.S. economy after World War II, and consequently would treat much of the Great Depression as a change in trend, rather than as a deviation from trend. In this we follow the methodology adopted in Cole & Ohanian (2007).

2. Model solution

In this Appendix we formally derive all the relevant properties of our model which were presented in the text. We begin by presenting the solution to the consumer's problem of first choosing the aggregate values of consumption and investment, and then choosing its distribution between imported and domestic goods.

Households first decide how to allocate a limited budget between the two consumption goods. Its problem is to maximize 4.4 subject to a budget constraint of the form

$$P_{g,t}C_{d,t} + C_{m,t} \leq Y_t, \quad (2.17)$$

where Y_t denotes a limited budget which must

The household's Lagrangean is

$$L = [\alpha_d C_{d,t}^{\frac{\sigma-1}{\sigma}} + (1 - \alpha_d) C_{m,t}^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} + \eta_t [Y_t - P_{g,t}C_{d,t} - C_{m,t}]. \quad (2.18)$$

The first-order conditions give us:

$$C_{d,t} : \alpha_d \left[\frac{C_t}{C_{d,t}} \right]^{\frac{1}{\sigma}} = \eta_t P_{g,t} \quad (2.19)$$

$$C_{m,t} : (1 - \alpha_d) \left[\frac{C_t}{C_{m,t}} \right]^{\frac{1}{\sigma}} = \eta_t \quad (2.20)$$

By dividing the first condition for the second, we can express the optimal consumption of domestic goods as a function of imported goods:

$$C_{d,t} = C_{m,t} \left(\frac{\alpha_d}{P_{g,t}(1 - \alpha_d)} \right)^{\sigma}. \quad (2.21)$$

By substituting the last equation in the definition of the aggregate consumption index, we can express the consumption of imported goods as a function of total consumption, but first we must define a Dixit-Stiglitz price index (see Dixit & Stiglitz (1977)) which gives us the price of a consumption good composed by the optimal choice of $C_{d,t}$ and $C_{m,t}$. In our case, the formula for this aggregate price index is

$$P_t \equiv \left[\alpha_d^{\sigma} P_{g,t}^{1-\sigma} + (1 - \alpha_d)^{\sigma} \right]^{\frac{1}{1-\sigma}} \quad (2.22)$$

As such, by substituting Equation 2.21 into 4.4 and using 2.22, we have

$$\begin{aligned}
C_t &\equiv \left[\alpha_d C_{m,t}^{\frac{\sigma-1}{\sigma}} \left(\frac{\alpha_d}{P_{g,t}(1-\alpha_d)} \right)^{\sigma-1} + (1-\alpha_d) C_{m,t}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} = \\
&= C_{m,t} \left[\alpha_d^\sigma P_{g,t}^{1-\sigma} (1-\alpha_d)^{1-\sigma} + (1-\alpha_d) \right]^{\frac{\sigma}{\sigma-1}} \\
&= C_{m,t} \left\{ (1-\alpha_d)^{1-\sigma} \left[\alpha_d^\sigma P_{g,t}^{1-\sigma} + (1-\alpha_d)^\sigma \right] \right\}^{\frac{\sigma}{\sigma-1}} = \\
&= C_{m,t} (1-\alpha_d)^{-\sigma} P_t^{-\sigma} \Rightarrow \\
C_{m,t} &= C_t [(1-\alpha_d)P_t]^\sigma. \tag{2.23}
\end{aligned}$$

Substitute 2.23 in 2.21 in order to find $C_{d,t}$:

$$C_{d,t} = C_t \left[\alpha_d \frac{P_t}{P_{g,t}} \right]^\sigma. \tag{2.24}$$

A similar derivation gives us the formula for the investment goods demand, as well as the investment good price index:

$$P_{I,t} \equiv \left[\alpha_I^\mu P_{g,t}^{1-\mu} + (1-\alpha_I)^\mu \right]^{\frac{1}{1-\mu}} \tag{2.25}$$

$$I_{d,t} = I_t \left[\alpha_I \frac{P_{I,t}}{P_{g,t}} \right]^\mu \tag{2.26}$$

$$I_{m,t} = I_t [(1-\alpha_I)P_{I,t}]^\mu \tag{2.27}$$

With this we have the solution to the first part of the consumer's problem, that is, to find the optimal combination of intermediary consumption and investment goods as functions of its respective prices, price indexes and final consumption and investment. We now derive the solution to the second stage of the consumer's problem, to maximize utility given its budget constraint. The utility to be maximized is given by 4.2, and the budget constraint is given by 4.7, with the addition of the capital law of motion given by 4.6. The Lagrangian for this problem is:

$$L = \sum_{t=0}^{\infty} \beta^t \{ \log(C_t) + \kappa_t [r_t K_t + \pi_t - P_t C_t - P_{I,t} (K_{t+1} + (1-\delta)K_t) - \tau_t] \}. \tag{2.28}$$

The first order conditions for consumption and capital are:

$$C_t : \frac{1}{C_t P_t} = \kappa_t \quad (2.29)$$

$$K_{t+1} : \frac{P_{I,t}}{P_t C_t} = \frac{\beta}{P_{t+1} C_{t+1}} [P_{I,t+1}(1 - \delta) + r_{t+1}], \quad (2.30)$$

where we already substitute 2.29 into the first order condition for capital.

On the side of the firms, we have a simple profit-maximization problem. The firm takes the cost of its inputs as given, as well as the price of its output (that is, it is inserted in a perfectly competitive market). The solution to maximizing 4.9 is identical to both types of firms:

$$K_{i,t} : r_t = \gamma_i P_{i,t} K_{i,t}^{\gamma_i - 1}, \quad (2.31)$$

where $i = g, c$. As noted above, since capital is non-specific, consumers can choose the composition of their capital stock without any sort of adjustment cost. This implies that they will only accumulate both types of capital in equilibrium if their rental rate is equal at all times.

2.1 Steady state

In order to find the steady state of a model, we use the first order conditions and the equilibrium relations of said model in order to determine what would be the value of all the variables if they did not differ from one period to another (that is, if $x_t = x_{t+1} \forall t$, for all variables x). Unfortunately we are unable to find a purely analytical answer to this question, however we can easily find such answer by programming the relations we are going to find in a solver, such as the *fsolve* routine for *Matlab*. In order to program our routine, we first guess a value for P_g and then find the steady-state values of all the remaining variables as functions of P_g ³¹.

For starters, since we have P_g we can use 2.22 and 2.25 in order to find the steady state price indexes. Afterwards, we can find the steady state rental rate as a function of P_I and the structural parameters of our model, by using 2.30:

$$\frac{P_I}{PC} = \frac{\beta}{PC} [P_I(1 - \delta) + r] \Rightarrow r = \frac{P_I[1 - \beta(1 - \delta)]}{\beta} \quad (2.32)$$

We can then use (2.31) with $i = g$ in order to find K_g . We can also use 4.8 and 4.12 in order

³¹Notice that we have dropped the time subscript from now on; since all variables are constant over time along the steady state, the time subscript becomes redundant.

to find P_c as a function of K_c , and substitute this into 2.31 in order to find K_c . We can then use 4.12 to find P_c .

With both K_g and K_c we can find K , and use it to find I through the capital law of motion given by 4.6:

$$I = K - K(1 - \delta) \Rightarrow I = \delta K.$$

We can then use both types of capital in order to find the output of general and coffee goods, and use 4.11 to find the value of M . Afterwards, we use the household's budget constraint 4.7, the government's constraint 4.10 and the profit function 4.9 in order to find the aggregate resource constraint of the entire economy:

$$PC + P_I I = P_g Y_g + M. \quad (2.33)$$

We can use the resource constraint in order to find C , and finally use C and I to find the individual demands for each type of consumption and investment good, by using equations 2.24, 2.23, 2.26 and 2.27.

Since we are unable to find a proper analytical solution to all variables as functions of the model's parameters, we instead use the *fsolve* routine to find the value of P_g which allows for all the relations of our model to be valid.

The procedure described above is generic enough to work for the special cases described in the text, when we set $\alpha_I = 0$ and different values for λ . We next describe the technical side of the transition experiments performed in this work.

2..2 Transition dynamics

In order to study the behavior of the domestic economy as it adjusts to the Great Depression shock, we model this adjustment as a transition between two different steady states. The domestic economy begins at a pre-Depression steady state when the foreign income shock hits, afterwards it slowly adjusts to a new Depression-era steady state throughout the 1930s. The key factor in this adjustment is that the economy must respect the trajectories implied by the resource constraints 4.15, 4.13, 4.14 and 2.33, as well as the first-order conditions of the households and firms' problems, 2.29, 2.30 and 2.31.

We once again use the software *Matlab* in order to simulate the adjustment of our economy.

The logic of our solution is as follows:

1. We feed a guess $\{K_t\}_{t=0}^T$ to the program, as well as the steady state values of total capital;
2. We then use an iterative procedure to search for the sequence $\{K_t\}_{t=0}^T$ which guarantees that the first order condition 2.30 is respected, starting from the initial guess which we fed to the program. This procedure essentially solves 2.30 for $t = 0, 1, \dots, T - 1$ by taking into account that K_0 and K_T must equal their respective steady state values.

We once again use the *fsolve* routine to iteratively solve for the sequence $\{K_t\}_{t=0}^T$. By using a large enough value for T , we guarantee that our economy will converge to the new post-Depression steady state when we run this experiment under the assumption that foreign income does not fluctuate along the transition (that is, when we assume that foreign income is at its pre-Depression steady state at $t = 0$ and then it falls to its post-Depression steady state, and remains there from $t = 1$ to $t = T$).

This experiment can also be performed with the use of the empirical behavior of foreign income. We can do this by inputting the U.S. per capita GDP in place of Z_t in order to subject our model economy to the foreign income fluctuations of the Great Depression. The economy's adjustment to this sequence of shocks takes into account the optimal behavior of households and firms, as well as the resource constraints.

It is also easy to adapt this procedure to also account for the data we have on the share of coffee output which was burned annually by the government throughout the 1930s. By doing this we can study the interaction between the empirical foreign income shocks and the price-defence mechanism. When compared to a situation where the price-defence mechanism is not active, this simulation allows us to gauge if our model is adequately incorporating the mechanism.

Finally, we are also interested in determining alternative behaviors for λ_t in order to study if there is a way to better fit the model to the available data. We begin by defining an endogenous rule for the share of burned coffee which involves setting λ_t based on the performance of foreign income, in order to maintain coffee prices at their pre-Depression levels. We do this by setting the whole sequence of coffee prices equal to their initial steady state value and solving for the share λ_t at each period. We impose that this mechanism will only be activated for years when foreign income is below its linear trend, thus allowing for the domestic economy to benefit from favourable movements of foreign income.