Transfer Problem Dynamics:
Macroeconomics of the Franco-Prussian War Indemnity

first draft January 2002
this draft July 2003

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Abstract

We study the classic transfer problem of predicting the effects on the terms of trade, and the current account, of an international transfer. A two-country model with debt and capital allows for realistic features of historical transfers: they follow wartime increases in government spending and are financed partly by borrowing. The model is applied to the largest historical transfer, the Franco-Prussian war indemnity of 1871-1873. In these three years, France transferred to Germany an amount equal to 22 percent of a year's GDP. We investigate the ability of the model to account for the historical path of French GDP, terms of trade, net exports, and aggregate consumption. When combined with measured shocks to fiscal policy and productivity over the period, the model provides a remarkably close fit to the historical sample path. This makes a strong case for the dynamic general equilibrium approach to studying the transfer problem. More generally, our results provide striking evidence of the importance of international capital markets in the nineteenth century.

JEL classification: F32, F41, N14

Keywords: transfer problem, current account, terms of trade

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1. Introduction

Research on the transfer problem tries to predict the economic effects of a unilateral, international transfer, generally among governments. Although it dates back to the nineteenth century, the debate about these effects became best known with the Keynes-Ohlin controversy in the 1929 *Economic Journal*, which concerned German reparations after the 1914-1918 war. While this debate focused on the effects on the donor, more recent research has turned to development aid and been concerned with the effects on the recipient. Despite the transfer problem's widespread appearance in textbooks on international economics, though, there are very few quantitative studies of the effects of transfers, and none that uses a general equilibrium model that jointly predicts the terms of trade, the current account, welfare, and other macroeconomic variables.

Our goal in this paper is to study the dynamic effects of a transfer, for two reasons. First, a transfer can be thought of as an experiment which should shed light on the way to build models in open-economy macroeconomics. For example, the response of the current account to the transfer may help us assess the intertemporal approach to the current account or the related question of how to model market incompleteness or limits on international risk-sharing . Similarly, the response of prices to the transfer should be informative about general equilibrium models of the terms of trade (footnote: A standard reference on the intertemporal approach to the current account is Obstfeld and Rogoff 1995. See Backus, Kehoe and Kydland 1994a,b for modeling terms of trade movements.).

Second, transfers play important roles in economic history. The specific transfer we study – the Franco-Prussian war indemnity – was blamed by popular historians for everything from the German stock market crash of 1873 to slow population growth in France. We embed the transfer in a general equilibrium model with other shocks to try to isolate the effects of the transfer. Historical transfers generally followed wars. Identifying the economic effects of the transfer or reparations requires that we control for other shocks, such as those to government spending during wartime.

We argue below that the use of a standard dynamic general equilibrium open economy framework can contribute substantially to understanding the effect of the Franco-Prussian

War Indemnity. Using data from France over during the 1860's and 1870's, we can observe the historical evolution of the key macroeconomic aggregates, including GDP, Net Exports, and the Terms of Trade. We are also able to isolate a some of the key shocks during this period, including but not exclusively the transfer payment shock. While the transfer payment represented a huge macroeconomic shock to the French economy, the evidence suggests that there were other large shocks at the time. We have enough data to identify shocks to government spending (fiscal policy) and to aggregate productivity. Using these shocks, we can construct the model prediction for the sample paths of the French economy.

We find that the model is very successful in accounting the for the historical sample paths of the main macroeconomic aggregates. Both sets of shocks are necessary in this accounting, however. The transfer shock alone can account for the movements in the terms of trade and net exports, but cannot provide an adequate account of the path of GDP and aggregate consumption. On the other hand, fiscal and productivity shocks provide a reasonable account of the path of GDP and consumption, but fail to account for the movements in the terms of trade and net exports in the 1871-1874 period. But when we combine the transfer shock and fiscal and productivity shocks, we find that the model does a good job in accounting for all these macroeconomic aggregates.

An advantage of our approach is that we can investigate the role of international capital markets in the response to the transfer shock. By solving a version of our model when capital markets are shut down, we can assess how different would the adjustment to the transfer have been without capital markets. We find that the response of the model economy without international capital markets is completely counterfactual, relative to the historical sample path. This presents quite powerful evidence of the well-functioning role of international credit in late 19th Century Europe.

Section 2 gives background and sources for previous research on the transfer problem. Section 3 explains why we adopt the Franco-Prussian war indemnity for study, and gives some associated history. Section 4 develops a static, two-country model of the effects of the transfer on the terms of trade. This setup is in keeping with most of the theoretical work on the transfer problem. Next, section 5 introduces debt and capital. Section 6 contains numerical results from the dynamic model, and compares its sample paths to those from history. Section 7 contains a preliminary discussion of other shocks. Section 8 comments on the evidence of the transfer's effects in Germany. Section 9 concludes.

2. Research on the Transfer Problem

Keynes (1929) argued that a transfer leads to a deterioration in the donor's terms of trade. Its government's increase in supply through the non-market transfer drives down the price of its exports. In Keynes's view, this added to the burden of the transfer. Ohlin's (1929) response was that the income effects may outweigh this. The recipient is richer as a result of the transfer, and so spends more on the donor's goods. The donor is poorer, and so spends less on the recipient's goods. So the donor's terms of trade may improve. The large, subsequent literature, completely reviewed by Brakman and van Marrewijk (1998), is generally static and theoretical. It is concerned with numerous factors like distortions, third parties, public goods, or tied aid. Brakman and van Marrewijk (chapter 3) describe the general presumption that a donor's terms of trade will deteriorate if all goods are normal in both countries.

In this research, intertemporal trade is generally ruled out. But historical transfers often were financed through borrowing, rather than paid from current national income. In the original debate on the transfer problem, for example, Angell (1930) reviewed prospects for German reparations and their finance by international borrowing. Relative to the large literature on the transfer problem, our modeling approach is very benign when it comes to the array of goods and preferences. Instead, we investigate changing the constraints and technology to allow lending and borrowing as well as capital accumulation. Intuitively, consumption-smoothing via borrowing should reduce the required adjustment in the current terms of trade in response to a transfer. We show that simply allowing for international lending and borrowing leads to a large revision in the predicted effects of a transfer.

Several papers have examined some implications of international borrowing.
Brock (1996) studied transfer problem dynamics and allowed for borrowing. He considered

a small open economy with a fixed terms of trade, and so focused on the adjustment of the relative price of non-traded goods. The original commentators on the transfer problem, such as Rueff (1929), emphasized the role of the terms of trade, so we adopt a two-country model and make that endogenous. Ritschl (1998) used Keynesian import equations to empirically study the effects of credit constraints implied by the Young Plan on Germany after 1929. White (2001) studied the reparations paid by France after the Napoleonic wars from the perspective of the intertemporal approach to the current account. He concluded that consumption was smoothed through international borrowing, but not by as much as predicted by theory. He also used a neoclassical growth model to estimate the costs of various ways of financing that transfer.

Finally, this work also is part of more general research on the determination of the terms of trade and the real exchange rate. Lane and Milesi-Ferretti's (2000) empirical work suggests links between external liabilities and the real exchange rate. Our empirical work seeks to isolate the effects of a specific shock – like reparations – to net foreign assets.

As mentioned in the introduction, empirical work on the transfer problem is rare. But two studies have estimated some of the effects of the Franco-Prussian war indemnity. Lévy-Leboyer and Bourguignon (1990, pp 243-247) studied the effects of both the Franco-Prussian war and the indemnity by adjusting and simulating an estimated, econometric model. Gavin (1992) suggested that consumption smoothing (the intertemporal approach to the current account) was relevant, but did not formally apply that approach. He used trends to gauge the effects of the transfer on French and German saving and investment during the 1870s.

3. The Franco-Prussian War Indemnity

Our application is to the Franco-Prussian war indemnity of 1871-1873. This transfer was virtually a lump sum, was of a large scale, was successfully made, and was largely free of default risk. The transfer took place in an environment of relatively free international capital markets. Data on the terms of trade and on macroeconomic aggregates are available for France and some of its trading partners for this period.

After the Franco-Prussian war, France owed an indemnity of 5 billion francs. Under the Treaty of Frankfurt, France agreed to pay this amount by 1 March 1875. Appendix A to this paper contains the relevant article of the treaty. In fact, most of the money was raised through two domestic bond issues in 1871 and 1872, which were heavily over-subscribed. Payment was complete during 1873. As Kindleberger (1993, p 245) noted:

> Particularly noteworthy in the light of the subsequent transfer problem with German reparations after World War I was that with no Keynes to tell them that transfer was impossible, the recycling and subsequent real transfer took place without any banker, economist, or government official giving thought to the question of whether the transfer was feasible.

The transfer consisted of bills of exchange and to a lesser extent gold, silver, and bank notes. The purchase of these bills was financed by the issue of callable perpetuities. Many of these bonds were purchased by foreigners, and many French foreign asset holdings also were sold. Monroe (1919) gave a detailed description of the timing, source, and composition of payments.

According to Brakman and van Marrewijk's measurements (1998, table 1.7) this payment was the largest transfer in history, amounting to almost 23 percent of a year's GDP or two and a half times the annual government budget in France. In contrast, the German reparations payments of the 1920s amounted to about 2.5 percent of GDP, the Finnish transfers to the USSR in the 1940s to 4 percent of GDP, and the transfers from the former West to East Germany in the early 1990s to 4.25 percent of GDP. The Franco-Prussian indemnity was also large as a share of the recipient's GDP, for in 1870 Prussian/German GDP was only slightly greater than that of France.

The only comparable transfer was again made by France, but in 1815 after the

Napoleonic Wars. White (2001, table 5) shows that these reparations were 18-21 percent of GDP but constituted a larger share of exports than the indemnity of 1871. They also were a very large burden because they took place at a time of high, real interest rates. We do not study this transfer because it took place over a longer time period (1815-1819) and because measures of the terms of trade and consistent national accounts are not available for that period.

Aside from the scale and pace of the transfer, the 1871 indemnity is notable also because there was virtually no sovereign debt risk associated with it. The timetable for the withdrawal of Prussian troops from French territory was explicitly linked to indemnity payments. Adolphe Thiers, the president of the republic from 1871 to 1873, was committed to early payment of the indemnity and was acceptable to Bismarck partly for that reason.

Most of the economic history on the indemnity has to do with the financial aspects rather than the macroeconomic effects. For example, Kindleberger (1993) and Landes (1982) discuss the financial arrangements for the transfer. But some historians have debated the economic costs to France of the indemnity and whether the German boom of the early 1870s can be attributed to the transfer. Eagly (1967) described the widespread view that the post-1873 depression was more severe in Germany than in France *and* that this difference was caused by the indemnity. He called this the 'potlatch' theory. In France, a rumour circulated that Germany was considering returning the indemnity.

Monroe (1919) presented some data which suggested that the German recession after 1873 was relatively severe. Norman Angell's 1913 best-seller, *The Great Illusion*, argued for the futility of reparations – and the Franco-Prussian war indemnity in particular – and of military power and conquest more generally. More thorough research on Germany has shown that its recession probably was no more severe than in other countries. O'Farrell (1913) argued that the mid-1870s business cycle was worldwide. Eagly gave data on output in several sectors (coal, iron) and showed that in real terms the German recession was in fact slightly milder than the French one. Even the stock market boom in Germany may have been due to an easing of incorporation laws, rather than to the indemnity. Unfortunately, German macroeconomic data for the 1870s remain incomplete, as Fremdling (1995) argues.

While these works have debated the macroeconomic data for Germany, they have not been concerned with formally modeling the effects of the transfer.

The historical record for France can best be seen through some time series graphs. The dark line in figure 1 shows France's annual current account balance as a share of GDP. Consistent data are available thanks to the achievement of Lévy-Leboyer and Bourguignon (1990); details are given in appendix B. During the early 1870s, France ran a current account surplus, averaging roughly 5 percent of GDP.

Next, we use the indemnity payments estimated by Lévy-Leboyer (1977): 1.435 billion F in 1871, 1.801 billion F in 1872 and 2.295 billion F in 1873, or 7.24%, 8.68%, and 11.1% of GDP. Subtracting these from the current account balance shows the balance net of the indemnity. As a share of GDP, this net figure is shown in the light line in figure 1. Clearly the indemnity was greater than the cumulative current account surpluses during those years, so a significant part of it was financed by selling assets or by borrowing internationally. This borrowing to finance a lump-sum loss of national wealth and smooth consumption seems consistent with the intertemporal approach to the current account. Of course, to formally test a model of the current account requires that we model other shocks as well. Both saving and investment, as shares of GDP. Both fell sharply from 1870 to 1871, but savings recovered more rapidly, as is also reflected in the current account series in figure 1. Gavin (1992) drew attention to these separate changes in saving and investment and their contributions to post-war current account surpluses.

Much of the theoretical work on the transfer problem has focused on the effect of a transfer on the terms of trade of the donor and of the recipient. Figure 3 shows the French terms of trade (solid line) and the trade balance as a share of GDP (dashed line). The terms of trade is defined as the ratio of import prices to export prices: $s \equiv p_m/p_x$. The figure shows that the French terms of trade deteriorated during the early 1870s, as predicted by standard models of international transfers (and, for the 1920s, by Keynes). Later sections of the paper examine whether theory can explain the quantitative change in the terms of trade. In assessing the effects of the transfer, we also control for other shocks, such as the wartime jump in government spending as a share of GDP, which also is shown in figure 2 (dotted line).

The theory applies to per capita measures, and so we deflate using Mitchell's (1998) mid-year estimates. In many applications, this transformation would not matter, for French population stagnated during this period, growing by only 0.36% per year 1861 to 1866 and by 0.54% per year from 1872 to 1876. In this case, though, we need to adjust for the loss of Alsace and Lorraine in 1871, as the Mitchell data do. Those regions comprised roughly 4% of French population. Although they comprised a larger share of GDP because of their relative industrialization, we have no way of measuring regional output.

Figure 3 shows estimates of the paths of real, per capita output and consumption. These series are measured by dividing the nominal series by the cost of living and the interpolated population series. The solid line is real output, while the dotted line gives a measure of aggregate consumption. Both series dropped sharply during the war, then recovered. Output was disrupted by the occupation and loss of Alsace-Lorraine, by the siege of Paris, by the Paris Commune, and by the political uncertainty associated with the founding of the third republic. Figure 3 suggests that the degree of consumption smoothing in fact was very limited, as the path of real consumption parallels that of real output. This evidence seems inconsistent with the intertemporal approach to the current account. Again, however, a complete model is needed to assess whether this path for consumption is consistent with a standard model of budgetting.

4. Preferences, Goods, and an Exchange Economy Example

To estimate the quantitative effects of the transfer, we begin with a static, exchange economy model. Most existing models of the transfer problem are static, so this exercise sets a standard of comparison, so that we can later show the effect of international borrowing. In addition, the static model introduces much of the notation used in the paper.

Two countries are denoted home (France) and foreign (either Germany or the world minus France). Foreign variables are labelled with an asterisk. Normalize so that the world population is unity. Then we may let the French population constitute a proportion

ω of the world economy. Each agent has an endowment of a non-storable, country-specific good: x in France and m abroad.

Market clearing in the two traded goods implies that domestic consumption and foreign purchases exhaust output each period:

$$\begin{aligned} x &= c_x + \left(\frac{1-\omega}{\omega}\right) c_x^* \\ m &= \left(\frac{\omega}{1-\omega}\right) c_m + c_m^* \end{aligned} \tag{1}$$

Notice that c_m denotes German or world exports to France, for example. Let s be the French terms of trade, expressed as the ratio of import prices to export prices. In the traditional theoretical models of the transfer problem, there is no lending and borrowing, so trade must balance each period:

$$(\frac{1-\omega}{\omega}) p_x c_x^* = p_m c_m + p_x T,$$

or

$$(\frac{1-\omega}{\omega}) c_x^* = s\, c_m + T, \tag{2}$$

An increase in the transfer T requires an equal increase in the French trade surplus.

French consumers consume an aggregate c composed of c_x of domestic goods and c_m of imports. This aggregate is given by:

$$c(c_x, c_m) = \left[\mu^{\frac{1}{\lambda}} \omega^{\frac{1}{\lambda}} c_x^{1-1/\lambda} + (1-\omega)^{\frac{1}{\lambda}} c_m^{1-1/\lambda}\right]^{\frac{\lambda}{\lambda-1}}. \tag{3}$$

so that λ is the elasticity of substitution and $\mu > 1$ indicates a preference for home goods. The population weight ω enters this definition because country size determines the share of a country's consumption that comes from home goods.

Foreign consumption is of the same form:

$$c^*(c_x^*, c_m^*) = \left[\mu^{\frac{1}{\lambda}} (1-\omega)^{\frac{1}{\lambda}} c_m^{*1-1/\lambda} + \omega^{\frac{1}{\lambda}} c_x^{*1-1/\lambda}\right]^{\frac{\lambda}{\lambda-1}}. \tag{4}$$

In France, utility maximization yields:

$$\mu^{\frac{1}{\lambda}} \left(\frac{\omega}{1-\omega}\right)^{\frac{1}{\lambda}} \left(\frac{c_x}{c_m}\right)^{-\frac{1}{\lambda}} = \frac{1}{s} \tag{5}$$

and in Germany or the rest of the world:

$$\mu^{\frac{1}{\lambda}} \left(\frac{\omega}{1-\omega} \right)^{-\frac{1}{\lambda}} \left(\frac{c_m^*}{c_x^*} \right)^{-\frac{1}{\lambda}} = s. \tag{6}$$

Given endowments x and m and a transfer T, equations (1), (2), (5) and (6) determine consumptions c_x, c_m, c_x^*, c_m^*, and the terms of trade s. As a simple example, suppose there is no preference for home goods, so that $\mu = 1.0$. Then

$$s = \left(\frac{x}{m} \right)^{\frac{1}{\lambda}} \tag{7}$$

As in Backus, Kehoe, and Kydland (1994b) for example, the terms of trade depend only on the endowment ratio. There is no transfer effect on the terms of trade.

Any preference for home goods ($\mu > 1.0$) implies that a transfer leads to a deterioration of the French terms of trade (a rise in s). Germany consumes more of its own export good, good m, with the transfer than France would have done, so the relative price of German goods rises and the French terms of trade deteriorate. For non-Cobb-Douglas preferences there is no analytic solution. Brakman and van Marrewijk (1998, chapter 3) provide a proof that home bias leads to a deterioration in the donor's terms of trade and a lucid discussion of the general static model. Note that country size in itself does not matter for the level of the terms of trade, because a rise in ω increases both the relative supply of French goods, and the relative size of French consumers.

Before describing the model's quantitative predictions, we also allow for nontraded goods. These were clearly important in France and its trading partners during the 1870s. For example, agriculture, services, transport, and government made up almost two-thirds of French GDP in 1870. While agriculture includes goods such as silk and wine that were traded internationally, these sectors also include a large, nontraded component.

Nontraded goods also played a role in the original Keynes-Ohlin debate on the terms of trade. Ohlin (1929), for example, argued that the presence of nontraded goods – and the possibility of changes in the internal terms of trade – influences the required changes in the international terms of trade. McDougall (1965) and Jones (1975) clarified this effect of nontraded goods in the static transfer problem.

Now suppose France has an endowment n of nontraded goods, while the foreign economy has an endowment n^*. French consumption is an aggregate of traded goods c_T and nontraded goods c_N:

$$c = \left(\gamma^{\frac{1}{\theta}} c_T^{1-\frac{1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} c_N^{1-\frac{1}{\theta}}\right)^{\frac{\theta}{\theta-1}}, \tag{8}$$

where the consumption of traded goods remains a composite of French traded goods as written in equation (3).

The consumer price index is:

$$p = \left[\gamma p_T^{1-\theta} + (1-\gamma) p_N^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{9}$$

The consumption-based price index of traded goods is

$$\begin{aligned} p_T &= \left[\mu\omega p_x^{1-\lambda} + (1-\omega) p_m^{1-\lambda}\right]^{\frac{1}{1-\lambda}} \\ &= \left[\mu\omega + (1-\omega) s^{1-\lambda}\right]^{\frac{1}{1-\lambda}}, \end{aligned} \tag{10}$$

where s is the terms of trade. The French budget constraint now is:

$$p \cdot c = x + p_N n - T, \tag{11}$$

where the transfer T is measured in traded goods and p_x is normalized to one.

Now the internal terms of trade, the relative price of traded to nontraded goods, is given by:

$$\left(\frac{\gamma}{1-\gamma}\right)^{\frac{1}{\theta}} \left(\frac{c_T}{c_N}\right)^{-\frac{1}{\theta}} = \frac{p_T}{p_N}. \tag{12}$$

The nontraded good is given by an endowment n, so that

$$n = c_N. \tag{13}$$

Markets clearing conditions for traded goods (1) continue to apply.

Similar conditions apply in the starred, foreign country except that their preference over goods x and m is the reverse of that of the French. Thus, for example, the traded goods deflator in Germany is:

$$\begin{aligned} p_T^* &= \left(\omega p_x + \mu(1-\omega) p_m^{1-\lambda}\right)^{\frac{1}{1-\lambda}} \\ &= \left(\omega + \mu(1-\omega) s^{1-\lambda}\right)^{\frac{1}{1-\lambda}}. \end{aligned} \tag{14}$$

Then the model's equations can be solved for the nine unknowns: s, p_N, p_N^*, c_N, c_N^*, c_x, c_x^*, c_m, and c_m^*. And the consumption of individual goods may be aggregated to give aggregate consumption.

For our numerical example, the parameters are set as follows. France's share of world GDP is $\omega = 0.165$ (based on France's share of GDP in the developed world in 1870, estimated from Maddison 1991, tables 1.1 and B.1). We calculate that the ratio of exports to GDP for France in 1870 was 15 percent. The value of μ which reproduces this ratio is 8. The elasticity of substitution between traded exports and imports is $\lambda = 1.5$, as in Backus, Kehoe, and Kydland (1994a), and the elasticity of substitution between traded and nontraded goods is set at unity, so that $\theta = 1.5$ (see below for discussion). Allowing for some traded component of the agriculture sector, we use an estimate of the nontraded goods sector at 50 percent of GDP, so we set $\gamma = 0.5$.

Table 1 gives some results from the static model, and compares them with evidence for France. The table shows the model predictions for the change in the terms of trade and consumption. The first two rows describe the case in which France is 16.5 percent of the world economy, and transfers of 7.4 percent or 22 percent of GDP. These are the shares of 1870 GDP given by the 1871 transfer and by the cumulative transfer respectively. Consequently, when the transfer is a large share of French GDP and France has a modest share of world GDP there is an enormous decline in the relative demand for France's export good (good x), because the rest of the world has no such bias towards French goods.

The model predictions can be compared to the evidence for France in the lower panels of table 1, since the data represent the terms of trade with the rest of the world, rather than with Germany. The static model predicts a much larger deterioration in the terms of trade and a much larger fall in consumption (whether on impact or cumulatively) than were observed historically. The actual path for consumption fell from 1870 to 1871 but then grew in subsequent years. The historical fall in consumption would be even smaller if we measured it relative to a trend growth path.

Two features obviously are missing from the model. First, in the static model there is no ability to cushion the impact of a transfer through international borrowing. The transfer thus has a very large effect on both the terms of trade and on French absorption. Second,the model is missing other shocks. Figure 3 shows large movements in the French terms of trade during other years, when transfers did not occur. We need to identify other shocks to explain those fluctuations, and so must control for those shocks to try to isolate the effects of the transfer.

We deal with each of these issues in turn. First, we examine the effects of the transfer on the terms of trade and consumption in a dynamic economy with debt and capital.

5. International Debt and Capital Dynamics

In this section we extend the model to allow for international debt, physical capital accumulation, and variable labour supply. Let household preferences be given by:

$$U = \sum_{t=0}^{\infty} \beta^t \left(\frac{c_t^{1-\sigma}}{1-\sigma} + \eta \frac{(1-h_t)^{1-\nu}}{1-\nu} \right), \tag{15}$$

with σ, $\nu > 0$ and as before $c = c(c_T, c_N) = c(c_x, c_m, c_N)$. The discount factor, β, is common across countries. Households consume a composite goods bundle and supply labour, h_t.

Bonds are the only internationally traded asset. Therefore households in France cannot diversify away the income effects of a transfer. The higher French tax burden caused by the transfer must be fully met by French tax-payers. The budget constraint for France thus is:

$$p_t c_t + b_{t+1} + p_t i_{xt} + p_t i_{Nt} = w_t h_t + r_{xt} k_{xt} + r_{Nt} k_{Nt} + (1 + r_t) b_t - p_t \tau_t. \tag{16}$$

As in section 3, the domestic export good is the numeraire, so $p_{xt} \equiv 1$. Thus international bonds are denominated in domestic exports. The consumer purchases the composite consumption good, c_t and invests in capital in the export sector and in the non-traded sector. The return on international bonds, r_t is denominated in domestic exports. Taxes collected by the government are given by τ_t.

Capital accumulates as follows:

$$k_{xt+1} = \phi\left(\frac{i_{xt}}{k_{xt}}\right) k_{xt} + (1 - \delta) k_{xt}, \tag{17}$$

and

$$k_{Nt+1} = \phi\left(\frac{i_{Nt}}{k_{Nt}}\right)k_{Nt} + (1-\delta)k_{Nt}. \tag{18}$$

In this technology, $\phi' > 0$, $\phi'' < 0$, and $\phi(\delta) = \delta$. This captures adjustment costs of capital that prevent capital moving between sectors and across borders with unrealistic speed.

In an optimal consumption plan, traded goods consumption is divided among domestic and foreign goods as:

$$c_{xt} = \mu\omega\left(\frac{1}{p_{Tt}}\right)^{-\lambda} c_{Tt}, \tag{19}$$

and

$$c_{mt} = (1-\omega)\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda} c_{Tt}. \tag{20}$$

Total consumption is divided among traded and non-traded goods as:

$$c_{Tt} = \gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta} c_t, \tag{21}$$

and

$$c_{Nt} = (1-\gamma)\left(\frac{p_{Nt}}{p_t}\right)^{-\theta} c_t. \tag{22}$$

Saving decisions stem from the usual Euler equations:

$$\beta \mathrm{E}_t\left[\frac{p_t c_t^{\sigma}(1+r_{t+1})}{p_{t+1}c_{t+1}^{\sigma}}\right] = 1 \tag{23}$$

Hours worked are chosen to satisfy:

$$\eta(1-h_t)^{-\nu} = c_t^{\sigma}\frac{w_t}{p_t}. \tag{24}$$

Capital in the export sector is chosen as:

$$q_{xt}c_t^{-\sigma} = \mathrm{E}_t\beta c_{t+1}^{-\sigma}\left[\frac{r_{xt+1}}{p_{t+1}} + (1-\delta)q_{xt+1}\right] \tag{25}$$

where $q_{xt} = 1/\phi'(i_{xt}/k_{xt})$ is the real price of a unit of capital in the export sector, in terms of the composite good, and r_{xt+1} is the rental rate on capital in the export sector. A similar relationship holds in the non-traded sector, with relative price q_{Nt}.

Firms face a static optimization problem, and simply maximize profits. Production functions are Cobb-Douglas, with exponent α in the export sector and κ in the non-traded sector. The profit-maximizing conditions for the two sectors are:

$$\begin{aligned} r_{xt} &= \alpha k_{xt}^{\alpha-1} h_{xt}^{1-\alpha} \\ w_t &= (1-\alpha) k_{xt}^{\alpha} h_{xt}^{-\alpha} \\ r_{Nt} &= p_{Nt} \kappa k_{Nt}^{\kappa-1} h_{Nt}^{1-\kappa} \\ w_t &= p_{Nt}(1-\kappa) k_{Nt}^{\alpha} h_{Nt}^{-\kappa} \end{aligned} \tag{26}$$

For simplicity, we assume that the government finances a transfer and government spending with a lump-sum tax. Its budget constraint is:

$$p_t g_t + T_t = p_t \tau_t. \tag{27}$$

The implicit assumption here is that government spending falls across sectors in the same proportion as private spending. The dynamic effects of the war and transfer in this model would be affected by the pattern of distorting taxes used to finance them. However, we lack detailed data on the government's revenues which would allow us to study the effects of the financing plan, along the lines originated by Ohanian (1997) for the twentieth-century U.S.

Following recent, numerical methods in open economy macroeconomics, developed by Schmitt-Grohé and Uribe (2001) and Kollmann (2001), we assume that there is a debt-elastic differential between the home and foreign rates of interest. Thus, denoting r_t^* as the foreign rate of return (in terms of good x), the relationship between French and world interest rates is given by

$$(1 + r_{t+1}) = (1 + r_{t+1}^*)\psi(b_{t+1} - \bar{b}) \tag{28}$$

where the function $\psi(b_{t+1} - \bar{b})$ satisfies $\psi(0) = 1$, and $\psi'(.) < 0$. This function captures the idea of an upward-sloping supply curve of foreign credit. When the economy is a net borrower, it faces an interest rate that is higher than the interest rate of its trading partner. When it is a lender, it receives an interest rate that is lower than that of the other country. This specification plays two roles. First, from a technical viewpoint, it eliminates the presence of a unit root in the world wealth distribution, because $\bar{b}$ represents a steady-state level of net foreign assets for the home country. Second, it captures the presence of 'frictions' in the international capital markets. As these frictions become larger and larger, captured by a larger absolute value of ψ', the effect of the transfer is more and more contained within the period of the transfer, and the use of international capital markets to smooth out the impact of the transfer is reduced. As Schmitt-Grohé and Uribe (2001) show, this friction has an effect on the response of an open economy that is essentially identical to a number of alternative methods for dealing with a unit root in the wealth distribution, such as assuming endogenous time preference, or adjustment costs of international bond purchases. Empirically, Lane and Milesi-Ferretti (2001) have estimated a negative relationship between real interest rate differentials and net foreign assets for a panel of industrial and developing economies between 1971-1998.

In each country, labour can be allocated to the non-traded sector or to the traded sector:

$$\begin{aligned} h_t &= h_{xt} + h_{Nt} \\ h_t^* &= h_{mt}^* + h_{Nt}^*. \end{aligned} \tag{29}$$

The non-traded goods market clears in each country:

$$\begin{aligned} k_{Nt}^{\kappa} h_{Nt}^{1-\kappa} &= (1-\gamma)\left(\frac{p_{Nt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\ k_{Nt}^{*\kappa} h_{Nt}^{*1-\kappa} &= (1-\gamma)\left(\frac{p_{*Nt}}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*). \end{aligned} \tag{30}$$

Markets for each traded good clear:

$$\begin{aligned} k_{xt}^{\alpha} h_{xt}^{1-\alpha} &= \mu\omega\left(\frac{1}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\ &\quad + (1-\omega)\left(\frac{1}{p_{Tt}^*}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}^*}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*) \\ k_{mt}^{*\alpha} h_{mt}^{*1-\alpha} &= \omega\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}}{p_t}\right)^{-\theta}(c_t + i_t + g_t) \\ &\quad + \mu(1-\omega)\left(\frac{p_{mt}}{p_{Tt}}\right)^{-\lambda}\gamma\left(\frac{p_{Tt}^*}{p_t^*}\right)^{-\theta}(c_t^* + i_t^* + g_t^*). \end{aligned} \tag{31}$$

An equilibrium determines the time path of interest rates, relative prices of non-traded goods, the terms of trade, and wages, as well as the consumption, capital, employment for each country, and net foreign assets (footnote In principle, the small implicit costs associated with capital market frictions described in equation (29) should come out of domestic or foreign resources. But since we take a linear approximation around a steady state with $r = r^*$, these costs do not appear in the solution, so we ignore them in the description of the model).

For illustrative purposes, Table 1 showed static examples in which France and Germany comprise the world ($\omega = 0.5$) and examples in which there are third parties ($\omega = 0.165$) so that the calibration of country sizes is more realistic. Sections 6 and 7 next study the effects of the transfer on France in a dynamic economy where the rest of the world comprises Germany and all other countries. We thus continue to allow for third parties or bystanders, and calibrate the model accordingly. Its predictions then may be compared with French data, where the terms of trade and net exports are measured relative to the rest of the world, rather than on a bilateral basis with Germany.

Brakman and van Marrewijk (1998, chapter 6) surveyed theoretical work on the effects of third parties. Qualitatively, their presence leads to no change in the predictions for the terms of trade. Bhagwati, Brecher, and Hatta (1983) showed that third parties may lead to welfare paradoxes – in which France's welfare improves or Germany's deteriorates – only if there are inferior goods or backward-bending offer curves. These features are not present here.

6. Effects of a Transfer

In the dynamic model, there are additional parameter values that need to be determined. Table 2 describes the calibration. For many of the parameter values, we have no data at all pertaining to France and Germany in the 1870s, and we simply follow the common parameter assumptions of the international macroeconomics literature. For instance, we assume that the labour share of output in each sector is 0.64, and that the common rate of depreciation of physical capital is 10 percent in each sector. We assume that the steady-state real interest rate is 6 percent, so that in an initial steady state, $\beta = 0.94$, that the elasticity of intertemporal substitution in consumption is 1 (so that $\sigma = 1$). There is a range of estimates for the elasticity of substitution between export and import goods. We follow Backus, Kehoe, and Kydland 1992, in setting $\lambda = 1.5$. We follow Burstein Neves and Rebelo (2002) in setting the elasticity of substitution between non-traded and traded goods,θ, equal to unity (footnote: Other papers have reported lower estimates for the elasticity of substitution between traded and non-traded goods. For instance, Ostry and Reinhart (1992), for a group of developing economies, report an estimate $\theta = 0.76$. It makes little difference to our results if we use the lower estimate.). The parameter $\gamma = 0.5$ determines the observed share of expenditure falling on non-traded goods in the French economy. As before, $\mu = 8$ replicates the export/GDP ratio for France.

We calibrate capital adjustment costs so that the elasticity of Tobin's q in each sector with respect to the investment-capital ratio is 0.3, following recent literature (*e.g.* Bernanke, Gertler, and Gilchrist, 2000). For the function $\psi(b_{t+1} - \bar{b})$, we calibrate so that in a steady state, $\bar{b} = 0$. Then we may approximate (28) as

$$r_t = r_t^* - \chi b_t \tag{32}$$

Estimates of the parameter of the 'risk-premium' χ vary in the literature. Lane and Milesi Ferretti's estimates suggest a value of $\chi = .001$. Using a different approach, Schmitt-Grohé and Uribe's (2001) estimates translate into $\chi = .01$. A similar number is used by Benigno (2001). We find that the ability of the model to replicate the historical path of the terms of trade and the current account is greater for the higher value of χ. This suggests that, while capital markets were functioning in 19th century France, they were less frictionless than implied by some of the estimates from more recent data. Lévy-Leboyer and Bourguignon (1990, p 191) concluded that French interest rates were a decreasing function of the current account balance, but noted that the elasticity did not seem to be stable. Hence, we use the estimate $\chi = .01$ as our benchmark.

The model is solved by linear approximation around an initial steady state with zero net foreign assets (since we lack data on net foreign assets), and a trade balance of zero.

While in principle, linear approximation may be inappropriate in response to a transfer of this magnitude, previous literature has established that dynamic constant returns to scale economies of this type are quite 'smooth', so that the true dynamic solution behaves in an approximately linear fashion.

We now focus on the impact of an unanticipated transfer from France to Germany. From section 3, the estimates of the actual payments made, as a percentage of GDP, were 8.7, 7.48, and 9.17, in 1871, 1872, and 1873, respectively. We introduce this shock in the model as follows. In 1871, a previously unanticipated transfer of 8.7 percent of GDP is made, but agents then forecast accurately the payments of 7.48 and 9.17 of GDP for the succeeding two years. Since the full size of the indemnity payment was negotiated in 1871, clearly agents were able to forecast the occurrence of future payments. While the time path of payments may not have been fully predicted in 1871, in the presence of international capital markets, the time path of payments is approximately irrelevant (and exactly irrelevant when $\chi = 0$).

The solid lines in figure 4 illustrate the impact of the transfer in the baseline model. The figure shows the impulse response pattern for GDP, the terms of trade, the trade balance-GDP ratio, and consumption. The responses for GDP, the terms of trade, and consumption are measured in percentage points, while the response for the trade balance-GDP ratio is in levels.

The most obvious contrast with the static model of Table 1 is that the terms of trade and consumption response to the transfer is much smaller. The full transfer of 22 percent of GDP predicts a 50 percent terms of trade deterioration and a 30 percent fall in consumption in the static model. By contrast, in the economy with international borrowing, the analogous response of the terms of trade and consumption is only 6 percent and -2 percent, respectively. The most important reason for this is that the economy can use international capital markets to finance the transfer, so French absorption need not fall by the full amount of the transfer.

Figure 4 indicates that the the trade balance improves by about 3 percent of GDP. Since this falls short of the transfer made in 1871, the current account balance, including the transfer, must fall, as the economy goes into debt to finance the transfer. The improvement of the trade balance is generated by a fall in domestic consumption and a rise in domestic output. Output rises principally because the fall in consumption increases French labour supply. The effect of the transfer on investment (not shown in Figure 4) is more complex. Investment in the non-traded sector falls, because the fall in domestic consumption reduces non-traded output. But investment in the export sector increases, because the increase in employment increases the return to capital in this sector.

The full impact of the transfer on the terms of trade in the dynamic economy is attributable to a combination of shifts in world demand from French to German consumers, and to an expansion in the relative supply of French to rest-of-world exportable goods. Even in the case of balanced preferences ($\mu = 1.0$), the transfer still causes a terms of trade deterioration. This case is shown in the dotted lines in Figure 4. Although now there is no transfer-generated reallocation of world demand towards the German export good, there is still a 2 percent French terms of trade deterioration, because of the expansion in French export output. With endogenous production, the classic implication of a transfer, that it reduces the donor's terms of trade, does not hinge on home-good bias in preferences.

How does the effect of a transfer in the model accord with that seen in the historical data following the French indemnity payments? Figure 5 superimposes the baseline results from Figure 4 on the historical sample data from France. The data for GDP, the terms of trade, and consumption are de-trended for the 1860-1880 period, and the data shown represent deviations from trend. Although there in principle, the terms of trade may be stationary, it is clear from Figure 2 that there was a upward trend in the terms of trade for France over this period. Our aim is not to explain this trend, but rather the deviations that may be attributable to the transfer. For the net export share, we de-mean the series for the 1860-1880 period. Figure 2 showed that this share was consistently positive over this period. Since we approximate around a steady state with zero net debt, the steady-state share of net exports is zero in the model. Hence it is appropriate to remove the mean from this series.

Figure 5 establishes that the theoretical model with international capital markets generates a deterioration in the terms of trade that closely resembles the movement in the French terms of trade after 1871. Both in the data and the model, the terms of trade deteriorate by about 6 percent. In the model, this terms of trade deterioration is very persistent, since it is associated with a persistently lower consumption and persistently higher output in France, as the economy experiences a higher debt to GDP ratio, after borrowing to finance the transfer. In the data, the terms of trade falls back to its mean level within 4 years.

The movement of net exports in the data is also quite accurately captured by the model. The net export ratio rises by about 3 percent. However, the timing is slightly non-synchronous. The model predicts an immediate increase in 1871, as the transfer takes effect. In the historical data, there is a dip in the net export share 1871, but this is reversed in 1872, and there is a strong trade surplus for the next four years. Again, due to consumption smoothing, the trade surplus in the model is more persistent than that observed historically.

The movement of both consumption and output following the transfer is quite counterfactual. In the historical sample, both consumption and output are more than 12 percent below their mean levels in 1871. In the model, the effect of the transfer is to reduce consumption by about 2.5 percent, and *raise* output by about 1 percent. Output must rise, because the negative income effect of the transfer increases labour supply and reduces the real wage facing firms. The fall in consumption is muted by the presence of international capital markets. We also experimented with an alternative model specification in which there are no income effects on labour supply. In this case, the transfer leads to a fall in both consumption *and* GDP. But the size of the fall in GDP – and as before, consumption – is far less than observed in the data. The discrepancy between the model and historical sample with respect to the path of output suggests that it is important to account for the presence of other shocks. We return to this in the next section.

From the discussion and Figures so far, it is clear that the presence of international capital markets play a big role in determining the impact of the transfer. To illustrate this, Figure 6 shows the effect of the transfer in the dynamic model, but assuming a prohibitive friction in capital markets that prevents the economy from borrowing at all to finance the transfer. This differs from the experiment in the static exchange economy in that labour supply and investment can adjust in response to the transfer. Consumption falls by about 6 percent in the model, and output rises by about 2 percent. But the response of both the terms of trade and net exports are far greater in the model than the data. Without borrowing, the transfer would have necessitated a much larger trade surplus, and as a result, a much larger deterioration in the terms of trade for France.

7. Shocks

Like many transfers, the Franco-Prussian war indemnity did not take place in a placid macroeconomic era. During 1870 France experienced a sharp increase in government spending as its armies (first imperial, then republican) were mobilized. It also experienced the destruction of capital and the disruption of trade through the siege of Paris by the Prussian army, the occupation, the Commune in 1871, and the loss of Alsace-Lorraine. To isolate the effects of the transfer, we need to control for these shocks.

The work of economic historians also allows us to rule out certain shocks. First, tariffs did not change significantly in either France or its trading partners during the early 1870s. Smith (1980) and Verdier (1994) have analyzed the political basis for this stability of French commercial policy. France had liberalized trade with Great Britain after 1860 under the terms of the Cobden-Chevalier treaty. During the 1860s, France signed similar treaties with other countries, and Napoleon III issued decrees to abolish import duties on most primary products. And free trade continued after 1870 under the Third Republic. Similarly, protection was not a major tool for Bismarck until 1879.

Second, monetary policy also was not a source of shocks. During this period France suspended gold convertibility from August 1870 to December 1877, but in fact maintained a fixed exchange rate, with the franc rarely departing from its gold parity value. Thus, we do not model *differential* monetary policy as a source of dynamics.

However, further work may be needed on the *joint* monetary stance of France, Germany, Britain, and their trading partners in the mid-1870s. Flandreau (1996) carefully documented the steps by which Germany left the silver standard and France left bimetallism in favour of gold, as did the United States. This process led to correlated monetary changes across countries and worldwide deflation after 1872 as silver was demonetized. Although the indemnity payments were completed by September 1873, their macroeconomic effects may be entangled with the effects of this monetary regime change. We do not view the transfer as a *cause* of this change in monetary regime. Although Germany used some of the proceeds of the indemnity to acquire gold, France also demonetized silver while paying the transfer.

7.1 Government Spending

Beginning in 1869, French government spending doubled as a share of GDP, and again increased by one third in 1870-71. This share is shown in Figure 2, where the dotted line (right axis) shows data from 1860 to 1880.

Figure 7 illustrates the impact of government spending shocks in the model. The figure is constructed by de-trending the government spending to GDP ratio for 1860-1880, and using the deviations from trend as government spending shocks in the model. As to be expected, the big shocks take place at the time of war, in 1870 and 1871. Output rises because of the effects of the fiscal expansion on labour supply. The government spending shock directly crowds out consumption. Output is 2 percent above trend in 1871, and consumption is 1.5 percent below trend. The rapid fall in government spending after the war means that the movements in output and consumption are quite temporary. The direct expansion in demand for domestic goods leads to an improvement in the terms of trade. The net export to GDP ratio sharply deteriorates in 1871, but then recovers as the size of government spending diminishes.

While the wartime increase in government spending was very large, the overall impact on the economy is quite small, because the initial size of government in the economy is less than 5 percent of GDP. When we compare the impact of the government spending shocks to the historical sample (shown in the previous section), we see that government spending can play only a minor role in accounting for the macroeconomic variation in aggregates for France. Moreover, the extent to which government spending movements can account for the residual components of macro fluctuations unexplained by the transfer differs across variables. Government spending may help explain the greater fall in consumption than is implied by the transfer, but with respect to GDP, the impact of government spending increases the discrepancy between the model and the historical sample.

As section 5 mentioned, we lack a full decomposition of government revenues and so have adopted the budget constraint (28) and assumed lump-sum taxes. Partial revenue data catalogued by Mitchell (1998, table G) show that increases in excise and registration taxes accompanied the payment of the indemnity. Given the small size of the government sector, though, our findings would not be significantly changed by the modelling of distorting taxes.

A final reason why fiscal shocks may not have had a large effect on the terms of trade is that government spending rose and then fell in Germany, just as in France. Our model is, appropriately, not one of a small, open economy. Although we do not include this German shock, it would partially offset the effects of the French fiscal shock.

7.2 Growth Accounting without Capital or Labour

The second shock we study is one to total factor productivity (TFP) in both sectors of the French economy. Suppose that the aggregate production function now is:

$$y_t = z_t k_t^{\alpha} (h_t \xi^t)^{1-\alpha}, \tag{33}$$

where we do not distinguish between sectors, because they have the same exponents ($\alpha = \kappa$) in the calibrated model and because we do not have separate factor input data by sector. The technology now includes labour augmenting productivity that grows at constant rate ξ and a stationary, random, productivity shock z_t.

To measure these components of productivity change, we apply two features of the model to the data. First, Lévy-Leboyer and Bourguignon provide annual data on capital consumption or depreciation. In the model, this series is simply δk_t, so we multiply it by the calibrated value $\delta^{-1} = 10$ to provide a time series for k_t. Second, with competitive factor markets, the real wage satisfies:

$$w_t = (1 - \alpha) \frac{y_t}{h_t}. \tag{34}$$

We use the real wage series and the calibrated value of α (0.64) along with real output to solve for an estimate of the labour input, h_t. Finally, the productivity terms can then be found from the Solow residuals:

$$z_t(\xi^t)^{0.64} = \frac{y_t}{k_t^{\alpha} h_t^{1-\alpha}}. \tag{35}$$

Note three important features of this measurement. First, this scheme for isolating productivity shocks allows for changes in labour supply. For example, we have seen that the theory suggests the transfer or changes in fiscal policy may lead to such changes. Shifts in the labour supply curve do not invalidate this identification of productivity. Second, we are careful to refer to the measure h_t as the labour input rather than employment, so it reflects both hours and numbers of people employed. It does not reflect variation in utilization, though, which will show up in the measure of total factor productivity. Third, we do no separately model a partial destruction of the capital stock during the war. France was overwhelmingly rural, whereas most damage occurred in Paris, which constituted roughly 5 percent of France's population.

The implied capital and labour series, along with real output, are shown in Figure 8 for 1820-1913. Notice that the labour input declines in some years during the 1870s and 1880s. This evidence is consistent with the economic history, which emphasizes France's very slow or even negative population growth late in the nineteenth century. Table 3 shows growth accounting for France during the twenty years before and after the Franco-Prussian war. The slowdown during the 1870s and 1880s is well-known. Three-quarters of the slowdown in output growth is due to the decline in labour input growth. Despite our indirect identification of $\{h_t\}$, this finding again is roughly consistent with the economic history, which stresses France's early experience of declining birthrates and little immigration during this period. This consistency gives us some confidence in the implied, residual measures of productivity. The estimate of the growth rate of labour-augmenting productivity is $\hat{\xi} = 0.00493$ or 0.493% per year. The remaining, random component $\hat{z}_t$ also is shown in figure 8. Some of the fluctuations in this productivity measure are readily matched with other evidence on productivity. For example, $\hat{z}_t$ falls in 1870, which saw a severe winter, and rises in 1872, which saw good harvests in France.

Figure 9 shows the effects of the productivity shocks in the model. These are introduced in the following way. From the measured z_t shocks, we estimate a process $z_t = \bar{z} + \rho z_{t-1}$, over the 1820-1869 period, where $\bar{z} = 0.305$ and $\rho = 0.897$. This gives a predicted series $\hat{z}_t$. Beginning in 1860, and normalizing so that $z_{1859} = \frac{.305}{1-0.897}$ (which amounts to de-meaning the series for this sub-period), we derive a series of productivity shocks $z_t - \hat{z}_t$. We subject the model to these shocks, assuming persistence of 0.897, as in the estimated process.

Figure 9 also overlays the historical sample for GDP, the terms of trade, the net export ratio, and consumption, with the series predicted by the productivity shocks alone. The key feature of this Figure is that both observed GDP and consumption are quite well tracked by the model. This is of particular interest because these were the series not well explained by the transfer shock. In particular we found that GDP fell substantially in 1871 while the model with the transfer as the only source of shock predicted a small increase in GDP. According to Figure 9, the resolution lies in the occurrence of a large negative productivity shock in 1871. Likewise, the much bigger fall in consumption than predicted by the transfer alone can also be substantially explained by the size of the productivity shock in 1871.

With respect to the movement in the terms of trade and trade balance, the model driven by productivity shocks alone fails to track the historical sample as well. But note that the key discrepancies are in the 1870-1873 period. But this is exactly the time of the transfer. In the next section, we put all three shocks together to gauge the extent to which the model can reconcile theory and the historical evidence.

7.3 Sample Paths

Figure 10 illustrates the behavior of the sample paths for the model when subjected to shocks to government spending, productivity, and the transfer, measured as described in the previous sections. The figure also illustrates the sample paths that are implied by the model in the absence of the transfer, but including both government spending and productivity shocks. Finally, we include the historical sample paths.

The figure illustrates the extent to which the transfer of 1871-1873 can help to explain the behavior of the French economy during this period. In the absence of the transfer, it is clear that the model does a very poor job of explaining the historical paths of the terms of trade and net exports for 1871-1873. But with the transfer, the size and timing of movement both of these variables are quite well explained. In particular, the net export series predicted by the model are remarkably close to those in the data. While in the model without productivity shocks, the transfer alone tends to make net exports rise too early, relative to the sample path, the combination of the transfer with a large negative productivity shock causes the rise in net exports in the model to be delayed until 1871, exactly as in the sample path. By contrast, the terms of trade response in the model is somewhat delayed relative to the historical sample, again due to the negative productivity shock in 1871. However, the size of the terms of trade adjustment is exactly as in the sample.

The reason for the delay in the terms of trade deterioration in 1871, in the model, is the big fall in export good production associated with the negative productivity shock in both sectors. The fall in export good output tends to reduce s, while the impact of the transfer tends to increase s. The end result is that s in the model hardly moves at all in 1871, while in the sample s rises sharply. In fact, the movement in the terms of trade is better explained in the model *without* productivity shocks. One possible explanation for this is that productivity shocks were concentrated in the *non-traded goods sector*. Figure 11 repeats the exercise of Figure 10, but assuming now that productivity shocks occur only in non-traded goods. In this case both the size and timing of the terms of trade response in the model is extremely close to the sample path. At the same time, the movement in the net exports ratio still remains very close to the sample. In fact, Figure 11 shows quite close accord between the model and the sample path for all variables.

As a counterfactual, it is interesting to speculate how important a role was played by international capital markets in the movements on the economy, once we include all shocks in the model. Figure 12 illustrates the model with all shocks, but instead calibrating the risk premium response so high that the economy is in capital market autarky (as in Figure 6). It is clear that the model without capital markets cannot explain any of the series well.

Both the terms of trade and the net export ratio rise by an order of magnitude larger than seen in the sample. But also, the absence of international capital flows tends to exacerbate the fall in consumption in 1870, relative to the historical sample, and at the same time dampen the fall in output (due to the stronger income effects on labour supply).

8. German Evidence

A lack of macroeconomic data for Germany precludes our comprehensively testing the model by applying it there. For example, there are no series for the German terms of trade or current account prior to 1880. Hoffmann (1965) and Spree (1977) have constructed other macroeconomic aggregates at annual frequency, and attempted to adjust for the changing borders of the German state. Hoffmann's estimates of national product and its components have been criticized by Fremdling (1995), but no alternative measures are yet available. Appendix B again provides details of the measurements and data sources we adopted.

To see what the theory predicts for Germany, first imagine inverting figure 4, to show the effects of a transfer on the recipient rather than the donor. The theory implies that output falls relative to trend, because German labour supply falls as a result of a wealth effect. And consumption is predicted to rise because of the same wealth effect. In addition, the trade balance deteriorates, because part of the transfer is lent abroad, while the terms of trade improve.

Figure 13 shows estimates of expenditure shares in GDP. The share of net exports in GDP deteriorated in the early 1870s, as the transfer was being paid, and as predicted by the theory. While no terms-of-trade series is available, Zussman (2002) has constructed a German real exchange rate, and found a real appreciation from 1870 to 1873, which again is consistent with theory. On the other hand, figure 13 shows that there was no marked rise in the consumption share of GDP. Instead, the share of investment spending rose.

To try to explain these facts, we again examine other shocks. The share of government spending has two peaks, corresponding to the wars against Austria-Hungary (1866) and France (1870). According to the theory (as in figure 7), the increase in spending during the

Franco-Prussian war should have caused output to rise, and consumption to fall as a share of output. But then the postwar decline in government spending is predicted to lead to a decline in output and a rise in the consumption share. In Germany, unlike France, both fiscal contraction and the transfer are predicted to lead to increases in the consumption share. So allowing for the effects of fiscal policy deepens the puzzle of flat consumption and rising investment shares.

Finally, Germany also experienced rapid output growth from 1871 to 1873, accompanied by a stock market boom. Solow residuals (measured as in section 7.2) reveal the same pattern. The model predicts that consumption should rise less than output in response to positive shocks to productivity, so that the share of consumption falls. Our preliminary conclusion is that the effects of productivity improvements may have offset the effects of fiscal policy and the transfer. In sum, the early 1870s saw rapid output growth and an investment boom in Germany. Our research suggests that these cannot be attributed to the transfer. Instead, they may have been caused by improvements in total factor productivity. Candidate sources for this growth include liberalized rules of incorporation (in 1870), improvements in banking, efficiency gains from an expanded customs union, and railway unification.

9. Conclusion

The transfer problem is of interest for several reasons. It has played a large role in the development of theoretical models in international economics. In economic history, a range of economic effects have been attributed to transfers, without much formal modelling. Transfers can be viewed as large-scale experiments with which to test models of the terms of trade. And models of transfers are needed to predict the effects of current transfers, such as development aid. For example, the effect of foreign aid or the repatriation of labour income on a developing economy seems likely to depend on the degree of access to capital markets.

Our work has shown how the predicted effects of a transfer depend on (a) international borrowing and lending and (b) supply-side responses. We also found that evaluations of how much consumption-smoothing was possible through international capital markets require that we carefully control for shocks other than the transfer. Our results indicate that a dynamic general equilibrium model of the current account and terms of trade, and which combines the transfer with historical changes in government spending and in productivity, does remarkably well in matching the key features of French macroeconomic history after the Franco-Prussian war. This is so even though we have studied the nineteenth century using parameter values from the twentieth century, rather than selecting parameter values to improve the fit of the sample paths.

Given the vast size of the transfer, one might expect its effects to be glaringly obvious in the macroeconomic data, to the point where one need not even try to measure other shocks. Popular history often made this assumption, and attributed large economic effects to the indemnity. On the contrary, we find that changes in fiscal policy and in aggregate productivity are both needed and able in order to fit French and German macroeconomic history, especially with respect to the movements of GDP and consumption. This finding is striking evidence of the importance of international capital markets in the late nineteenth century.

Appendix A: Terms of the Treaty of Frankfurt

Article VII

A payment of five hundred million francs will take place within the thirty days following the re-establishment of the French government's authority in Paris. A billion francs shall be payable within the current year, and a half-billion at 1 May 1872. The remaining three billion francs will be payable by 2 March 1874, as stipulated in the preliminary peace treaty.

After 2 March of the current year, the interest on these three billion francs will be payable on 3 March each year, at a rate of five percent per year. Any part of the remaining three billion francs that is paid in advance will cease to accrue interest from the date of the payment.

All payments may be made only in the major commercial cities of Germany and are payable in gold, silver, notes of the central banks of England, Prussia, the Netherlands, or Belgium, bills of exchange, or cashable notes.

In France, the German government has fixed the value of the Prussian thaler at 3.75 francs. The French government accepts the conversion of the two countries' currencies at this rate.

[Translated by the authors. Our calculations include the separate Paris indemnity and but not the interest payments at 5 percent, for the latter were roughly offset by a payment to France for railways in Alsace and Lorraine.]

Appendix B: Data Sources and Definitions

France

Annual data for France are from Lévy-Leboyer and Bourguignon (1990). The following table gives the precise definitions of the measures we use, with the corresponding source in their monograph:

Measure	*Table*	*Series*
nominal GDP	A-III	1
net exports	A-III	5+6-7
investment	A-III	4+8
consumption	A-III	2
government spending	A-III	3
net foreign income	A-I	8
import prices	A-VI	4
export prices	A-VI	5
cost of living	A-IV	13
real wage	A-IV	14

Annual estimates of French population are from Mitchell (1998, table A5). These coincide with the quinqennial censuses and also reflect the loss of Alsace and Lorraine.

Germany

Annual data for Germany are from Hoffmann (1965) and Spree (1977). The real capital stock (in 1913 marks) is from Hoffmann, table 39. Real consumption, net investment, and government spending (1913 marks) are from Hoffmann, table 249. Real, net national product is from table 103, measured as the sum of output in different sectors. This series is rescaled by splicing it to the series on NNP, measured as the sum of expenditures, from table 249, which begins in 1880. Net investment and NNP are made gross by adding 10 percent of the capital stock series. Real net exports are then found from the national income-expenditure identity.

The real wage index (1900=100) and the index of German share prices are from Spree tables A3 and A16 respectively.

Volume indexes of exports and imports are found in Hoffmann (tables 129 and 131) and Spree (tables A39 and A40). While these series differ, they both show sharp deteriorations in the volume of net exports after 1871.

Table 1: Evidence on the Static Model

Transfer (% GDP)	Terms of Trade (% change)	Real Consumption (% change)
	Model Predictions ($\omega = 0.165$ $\mu = 8.0$)	
7.4%	19.66%	-11.51%
22%	58.3%	-34.72%
	France (1871-72 and 1871-74)	
7.4%	1.5%	11.7%
22%	2.9%	8.1 %
	France (1870-71 and 1870-73)	
7.4%	4.1%	-7.6%
22%	7.5%	0.2%

Notes: ω is the French share of world GDP; μ captures the home bias in the consumption of traded goods; non-traded goods prices comprise a share γ=0.5 of the price index; the elasticity of substitution between traded and nontraded goods is θ=1.25; the elasticity of substitution between exports and imports is λ=1.5. Consumption is measured on a per capita basis. Appendix B gives the sources for the historical data.

Table 2: Calibration

Parameter	Value	Description
σ	1	Inverse of elasticity of substitution in consumption
β	0.95	Discount factor (annual real interest rate is $(1-\beta)/\beta$)
ν	1.0	Inverse of elasticity of labour supply
η	1	Weight on labour supply in period utility
θ	1	Elasticity of substitution: traded and nontraded goods
λ	1.5	Elasticity of substitution: import and export goods
γ	0.5	Share of nontraded goods in consumption
μ	8	Home bias in traded-goods consumption
α	0.36	Share of capital in export sector production
κ	0.36	Share of capital in nontraded sector production
δ	0.1	Annual rate of capital depreciation (in both sectors)
$\phi'/(\phi''\delta)$	0.3	Elasticity of q with respect to the investment-capital ratio
χ	-0.01	Elasticity of real interest rate to net foreign assets
ω	0.165	Share of France in world GDP

Notes: Parameter values are discussed in section 5.

Table 3: Growth Accounting for France

Years	$\dot{y}$	$\alpha\dot{k}$	$(1-\alpha)\dot{n}$	$\dot{\text{TFP}}$
1850–1870	1.32	0.60	0.35	0.36
1870–1890	0.47	0.86	-0.29	0.50

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Figure 1: French Current Account/GDP

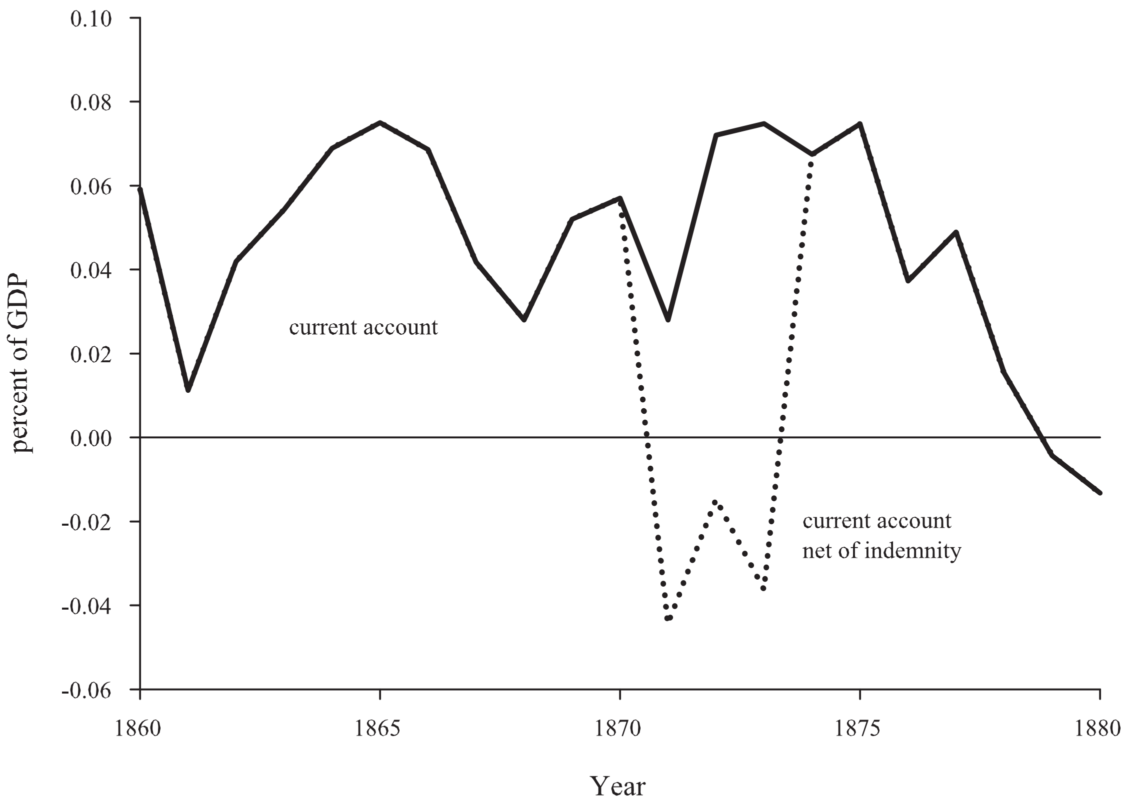


Figure 2: Terms of Trade, Net Export Share, and Government Spending Share

Figure 3: Real Output and Consumption

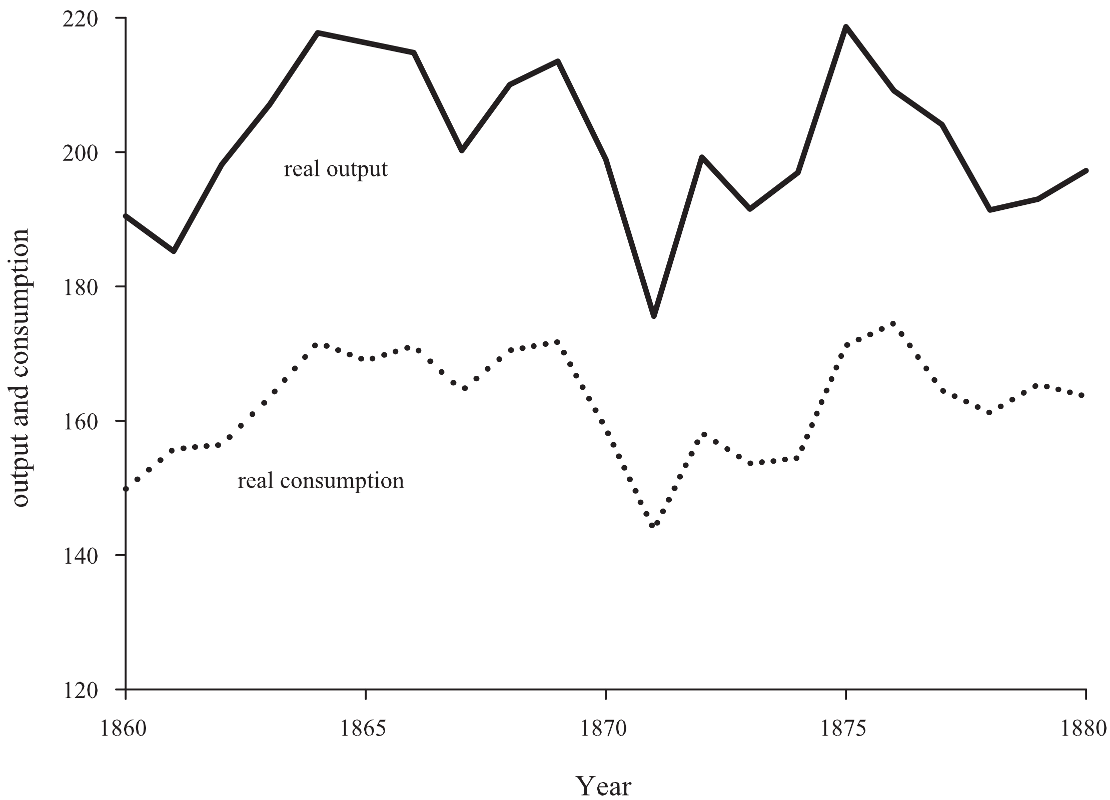


Figure 4: Responses to a Transfer

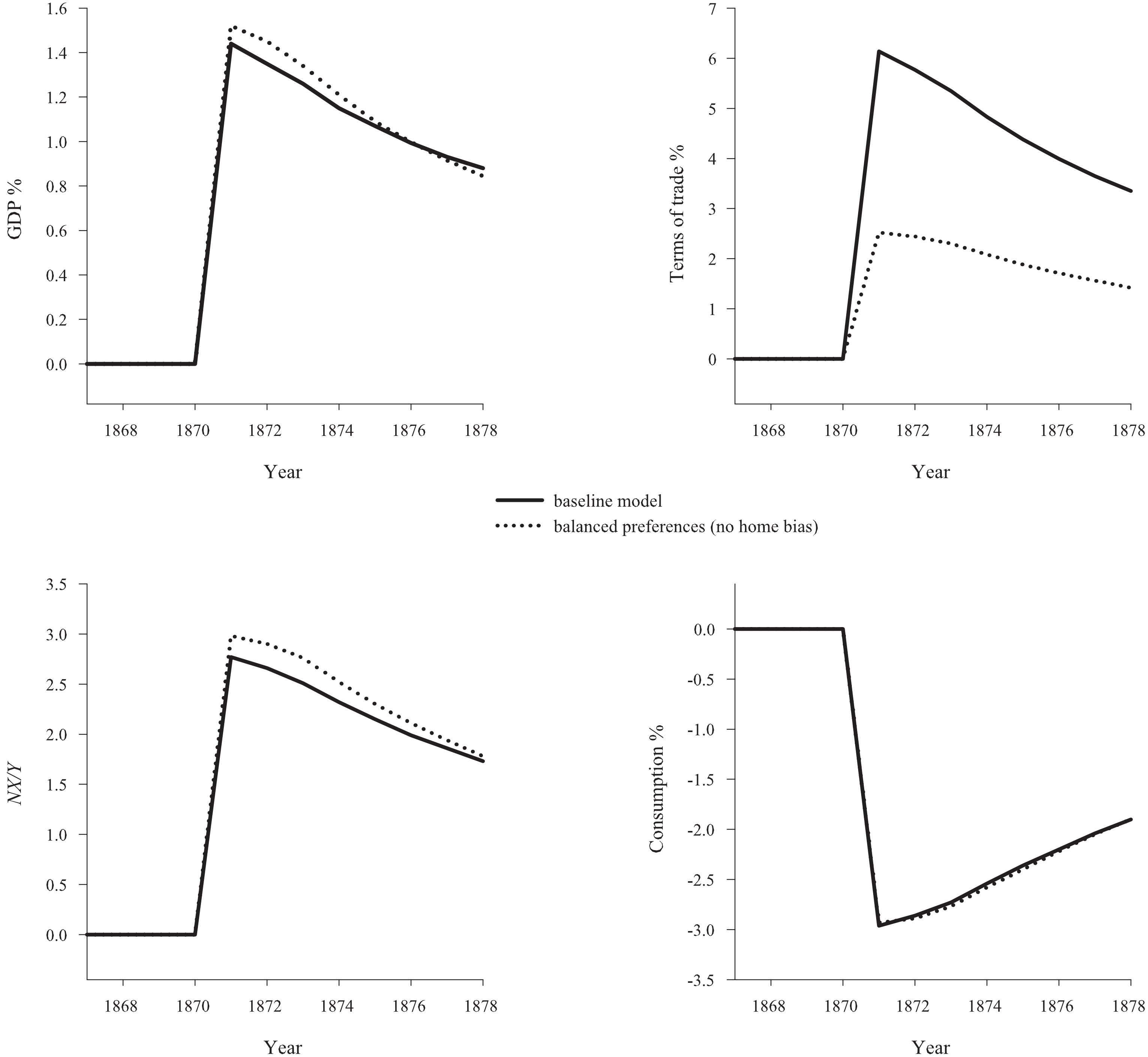


Figure 5: Baseline transfer effects and French history

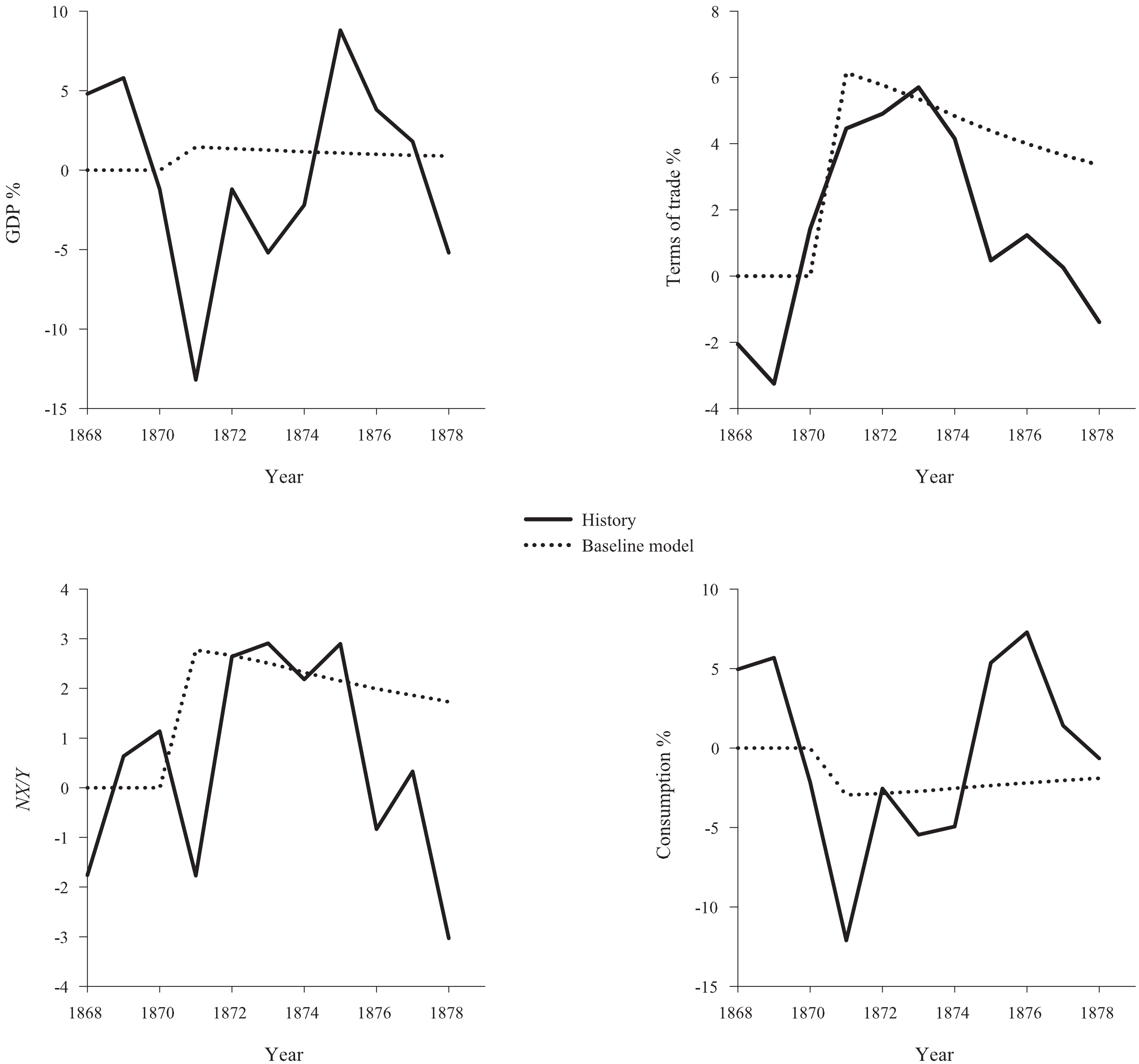


Figure 6: Transfer effects under capital autarky and French history

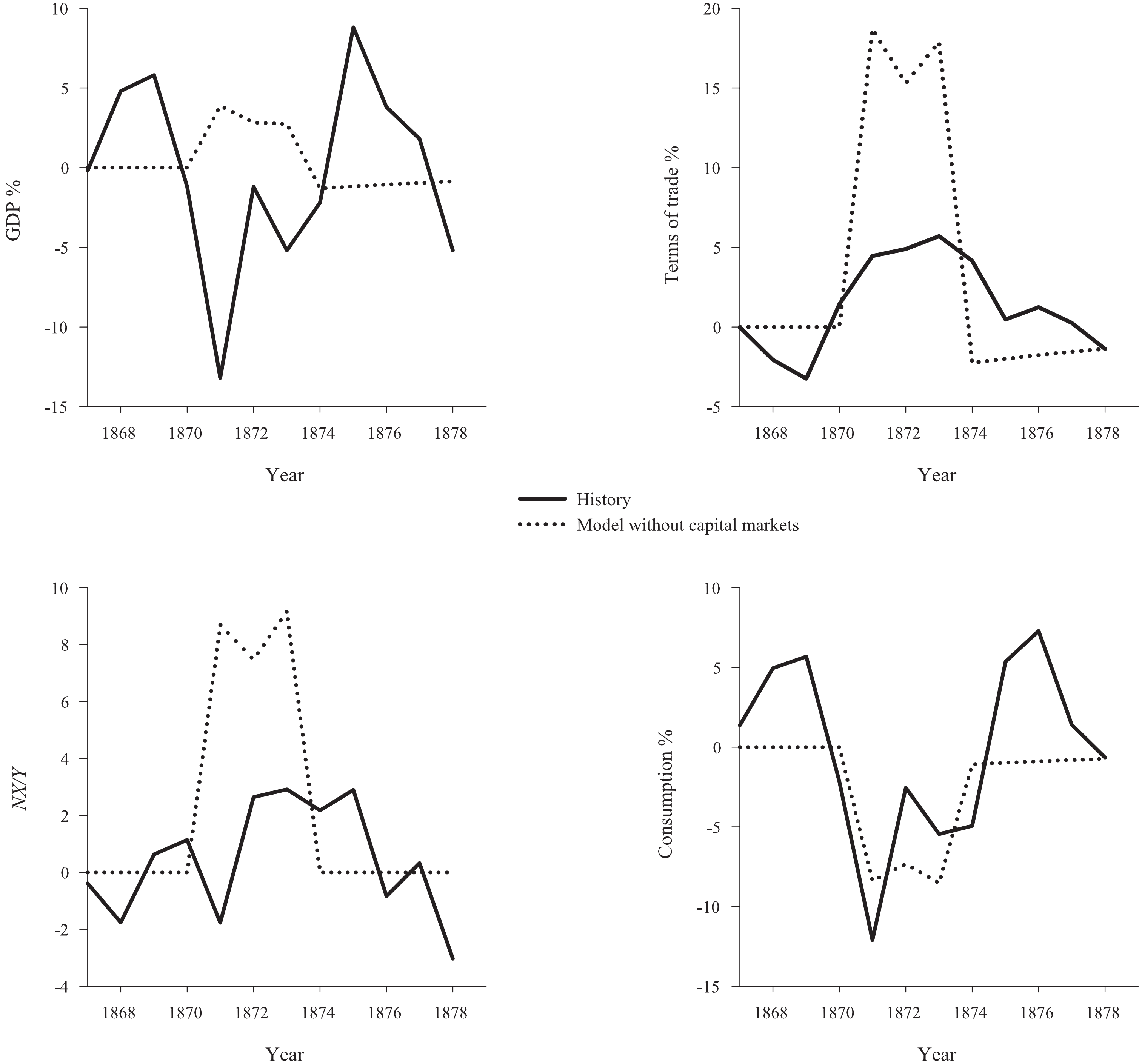


Figure 7: Responses to government spending shocks, baseline model

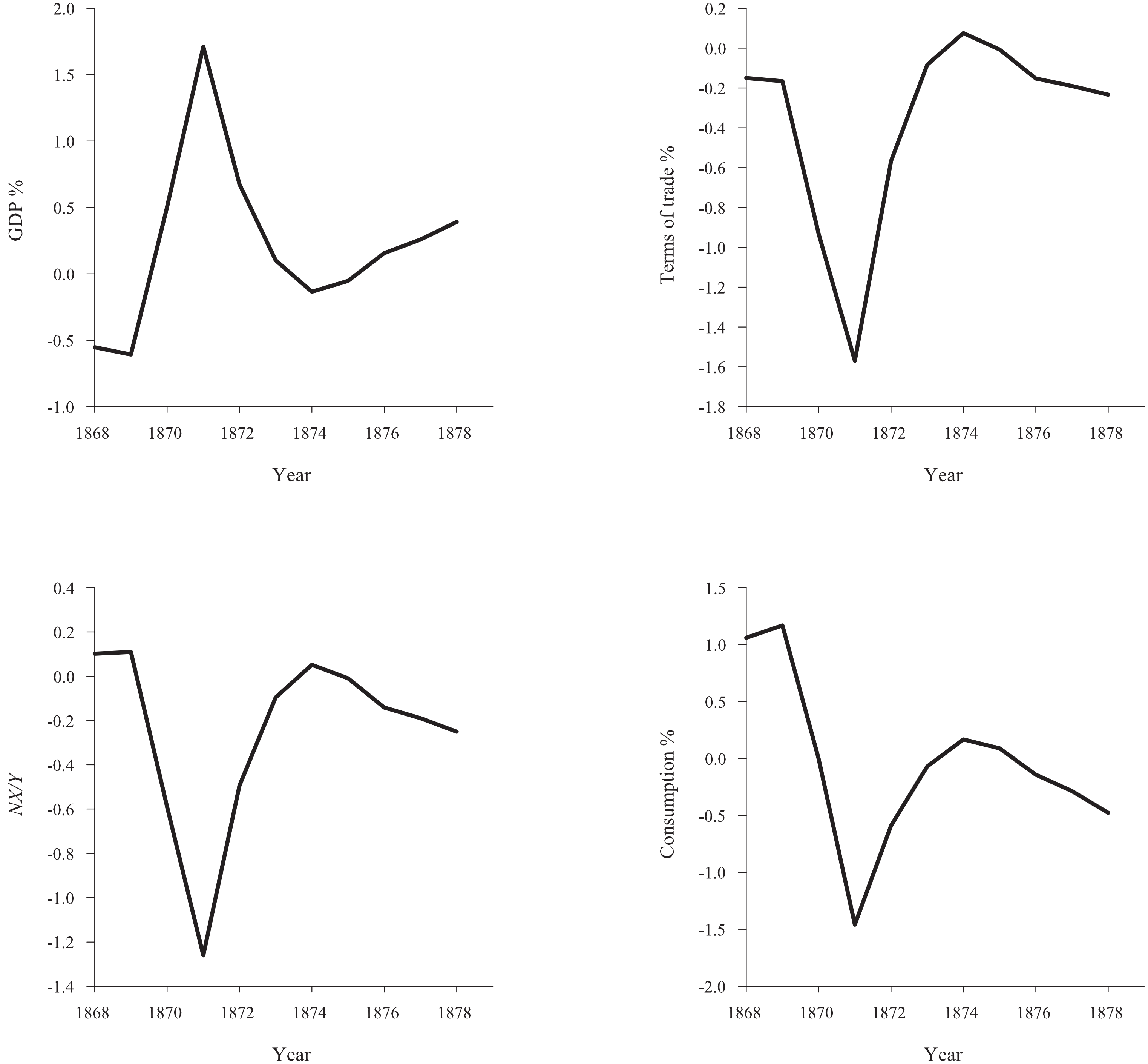
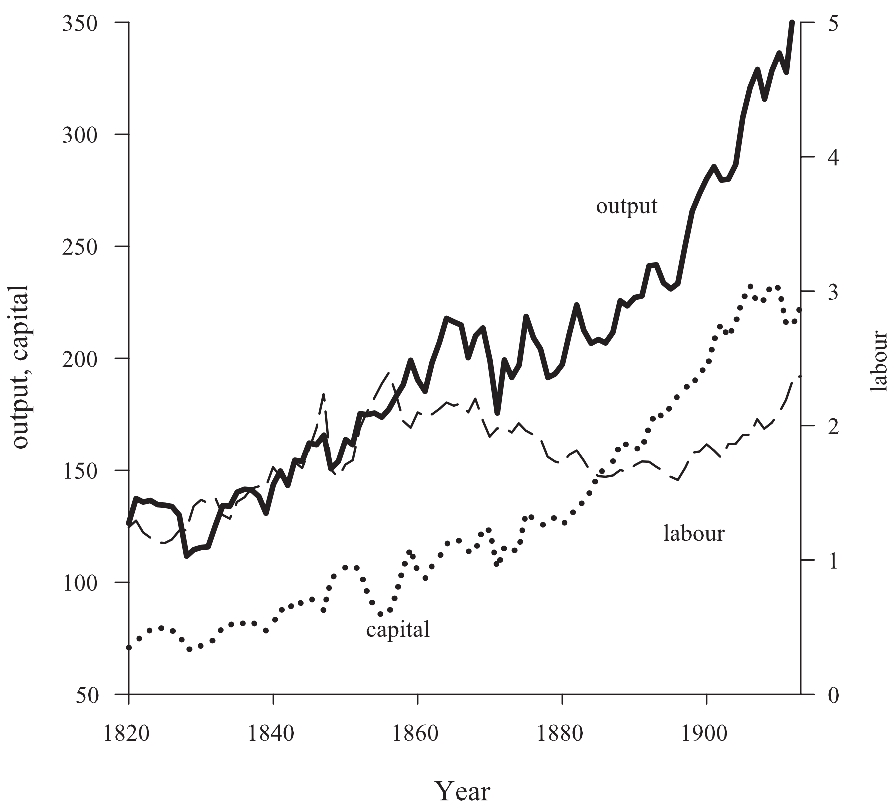


Figure 8: French "Growth Accounting"



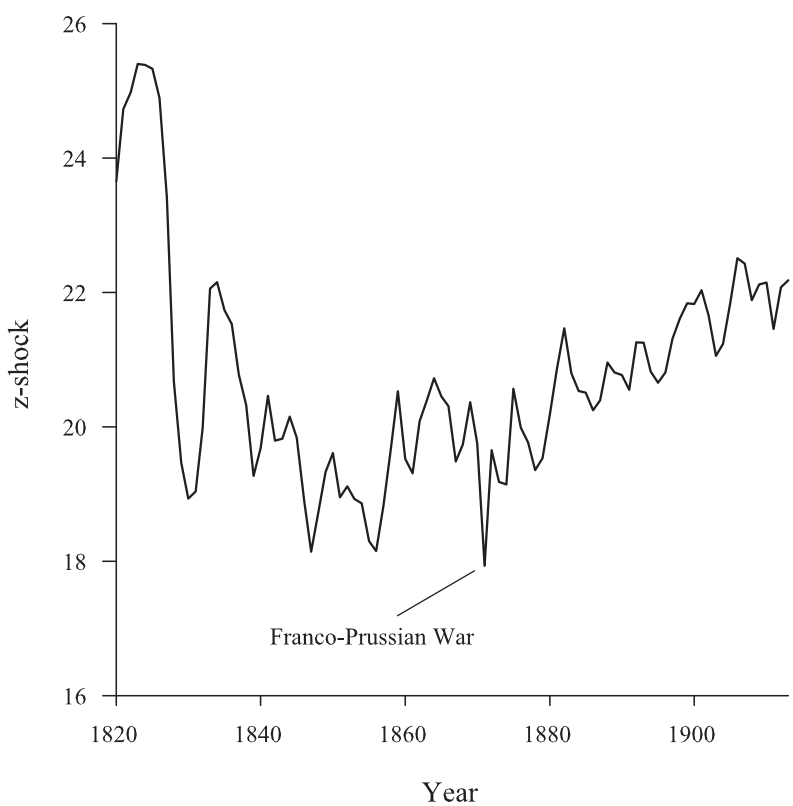


Figure 9: Productivity effects and French history

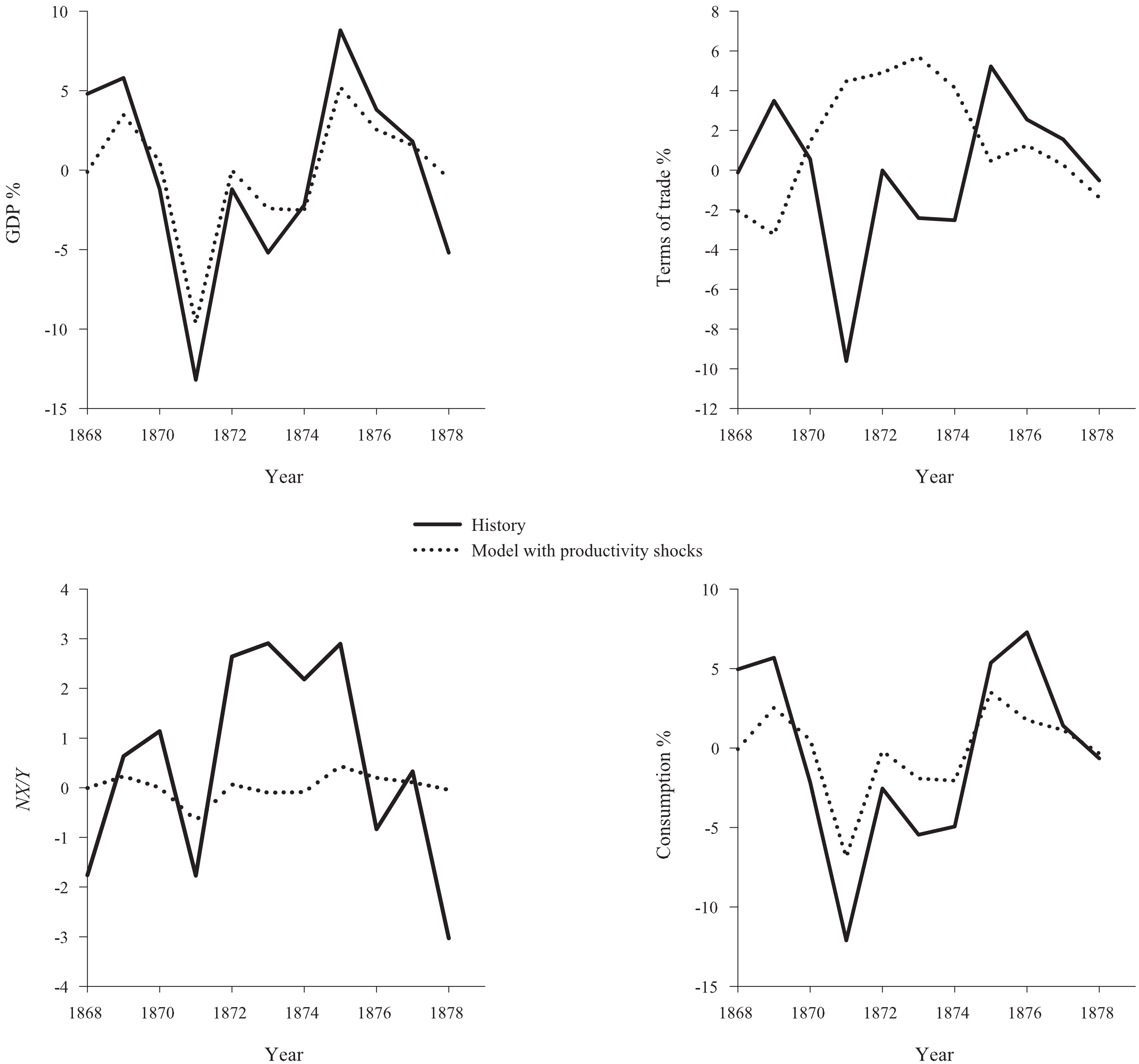


Figure 10: All shocks and French history

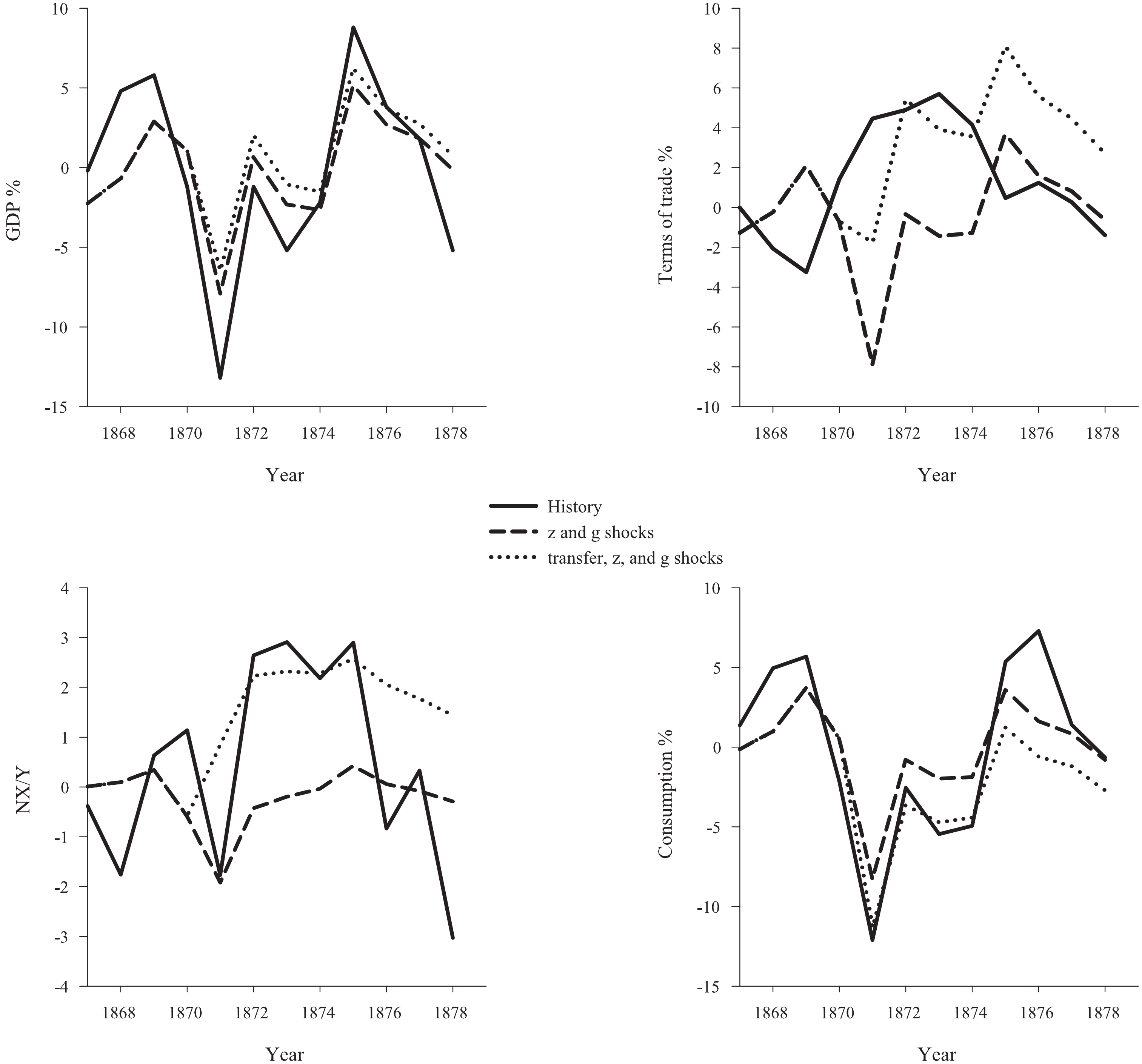
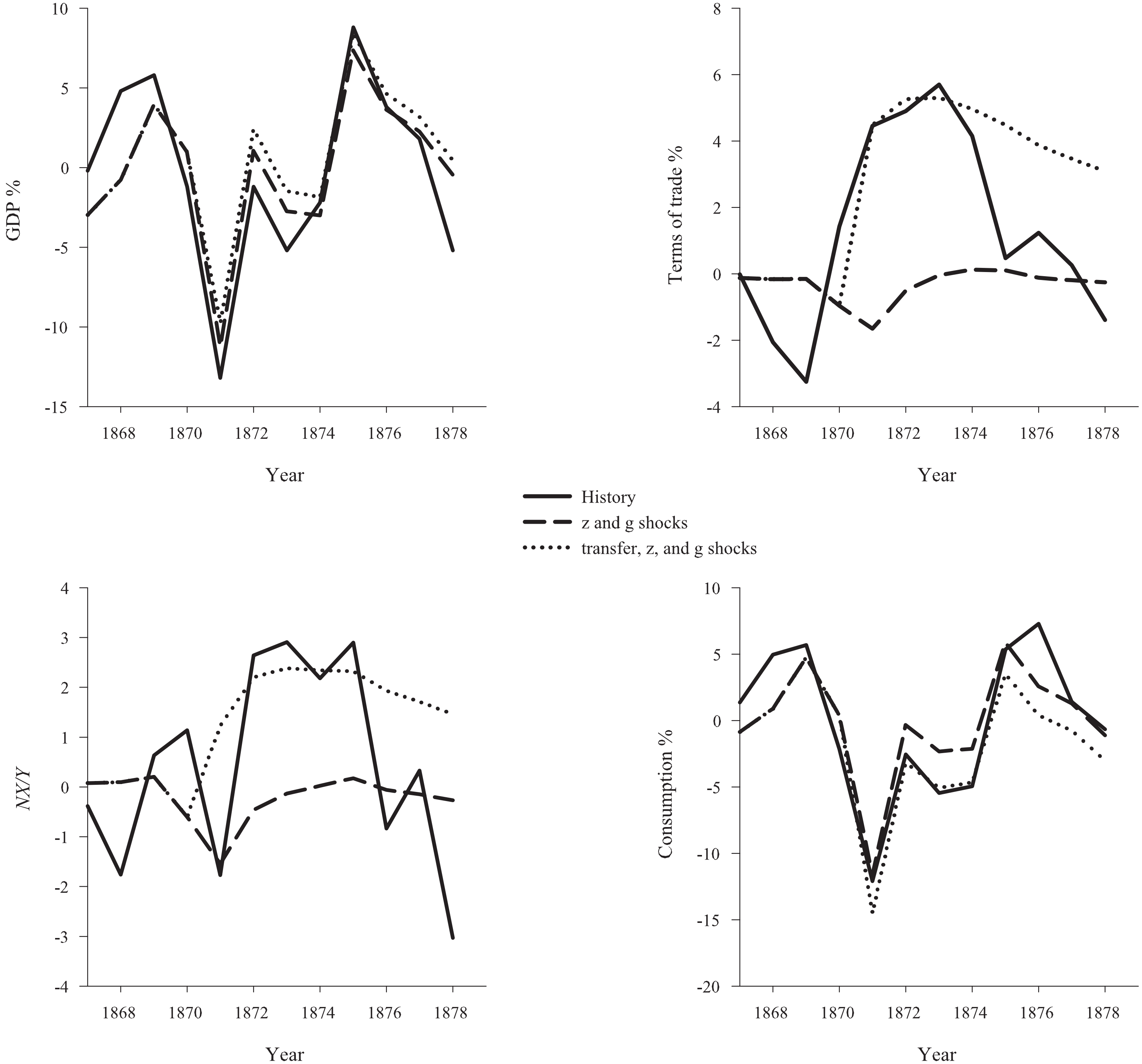
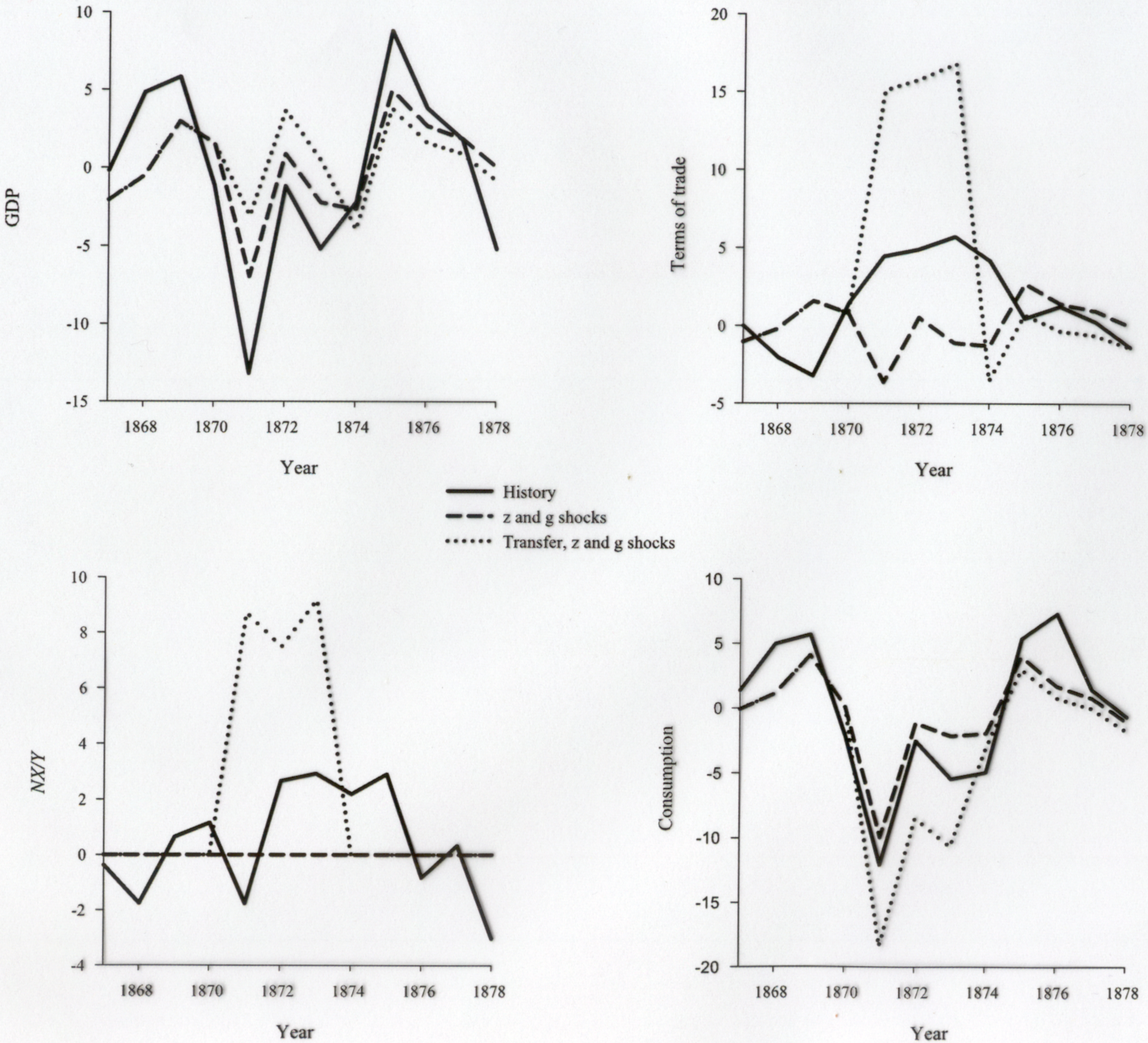


Figure 11: Productivity shocks in non-traded goods





GDP
Terms of trade
NX/Y
Consumption
Year
History
z and g shocks
Transfer, z and g shocks

Figure 13: German Expenditure Shares